# Flowering phenology and anthophilous insect community at a threatened natural lowland marsh at Nakaikemi in Tsuruga, Japan

AUTHOR(S):

KATO, Makoto; MIURA, Reiichi

CITATION:

KATO, Makoto ...[et al]. Flowering phenology and anthophilous insect community at a threatened natural lowland marsh at Nakaikemi in Tsuruga, Japan. Contributions from the Biological Laboratory, Kyoto University 1996, 29(1): 1

ISSUE DATE:

1996-03-31

URL:

http://hdl.handle.net/2433/156114

*Contr. biol. Lab. Kyoto Univ.*, Vol. 29, pp. 1-48, Pl. 1 Issued 31 March 1996

# Flowering phenology and anthophilous insect community at a threatened natural lowland marsh at Nakaikemi in Tsuruga, Japan

Makoto KATO and Reiichi MIURA

ABSTRACT Nakaikemi marsh, located in Fukui Prefecture, is one of only a few natural lowland marshlands left in western Japan, and harbors many endangered marsh plants and animals. Flowering phenology and anthophilous insect communities on 64 plant species of 35 families were studied in the marsh in 1994-95. A total of 936 individuals of 215 species in eight orders of Insecta were collected on flowers from mid April to mid October. The anthophilous insect community was characterized by dominance of Diptera (58 % of individuals) and relative paucity of Hymenoptera (26 %), Hemiptera (6 %), Lepidoptera (5 %), and Coleoptera (5 %). Syrphidae was the most abundant family and probably the most important pollination agents. Bee community was characterized by dominance of an aboveground nesting bee genus, *Hylaeus* (Colletidae), the most abundant species of which was a minute, rare little-recorded species. Cluster analysis on flower-visiting insect spectra grouped 64 plant species into seven clusters, which were respectively characterized by dominance of small or large bees (18 spp.), syrphid flies (13 spp.), Calyptrate and other flies (11 spp.), wasps and middle-sized bees (8 spp.), Lepidoptera (2 spp.), Coleoptera (1 sp.) and a mixture of these various insects (11 spp.). These flower guilds largely coincided with pollination guilds with some exceptions such as anemophilous grasses visited by specific syrphid flies. The flower-insect relationship in the marsh was discriminated from that in woodlands by rarity of specialized relationships and by prevalence of relationships between flowers and flies, most larvae of which grow in waterlogged habitats. Nakaikemi marsh is regarded as a rare, important wetland habitat not only harboring many endangered plant and anthophilous insect species but also fostering unique insect-flower relationships. The presence of some plant species originally pollinated by bumblebees nesting at forest floor suggests that the marshland should be conserved as a whole ecosystem uniting the marshland and the neighboring woodlands.

KEY WORDS flowering phenology / pollination / wetland / marsh / bees / Syrphidae

## Introduction

Lowland marshland is one of the most endangered ecosystems in Japan as well as in other countries (Dugan, 1990; Williams, 1990; Richards, 1990). The marshland in Japan has been reclaimed and utilized as rice field since more than 2000 years ago. These traditional rice fields were habitats of various aquatic and subaquatic plants and animals which originally inhabited in marshlands. Recent changes of cultivation system accompanied by overuse of insecticides and herbicides has exterminated many of these aquatic organisms (Red Data Book Committee Japan, 1989; Kadono, 1994).

Recent decline of population size and species diversity of inhabitants in wetlands appears to result in changes of interactions and partnerships between plants and animals. One example is *Primula sieboldii*, is a perennial which was widely distributed in swamps and marshlands along rivers but now is endangered. In Kanto District, this species survives only at one isolated site along Arakawa River, but its seed-set rates are very low due to extinction of its legal pollinators, i.e., long-tongued bumblebees (Washitani *et al.*, 1991; Washitani *et al.*, 1995). It is urgently necessary to understand original flower-insect relationships at lowland habitats since the condition

of almost all wetland habitats are rapidly degrading.

There are many studies on anthophilous bee fauna in Japan (Sakagami and Fukuda, 1973; Sakagami *et al.*, 1974; Matsuura *et al.*, 1974; Nakamura and Matsumura, 1985; Inoue *et al.*, 1990; Kakutani *et al.*, 1990; Kato *et al.*, 1990; Ikudome, 1992; Go'ukon, 1993). Most of these studies, however, were conducted in woodlands. The only two studies at wetland are made at cool-temperate meadows (Fukuda *et al.*, 1973; Kato et al., 1993). At natural lowland wetland habitats, anthophilous insect communities have not yet been studied.

In order to understand original flower-insect relationships at lowland wetlands and to propose ground plan to conserve wetland ecosystems, we studied flowering phenology and anthophilous insect community at Nakaikemi marsh in Hokuriku district, Japan. The marshland is one of only a few natural lowland wetlands barely left in Japan, and harbors various types of vegetations such as reed swamps, *Typha* and *Zizania* marshes, channels penetrating the marshland, traditionally cultivated rice fields and abandaned rice fields on a way of succession. The marsh is a habitat of many endangered aquatic and marsh plant species (Watanabe, 1989), most of which are extinct in most other localities.

In this paper, firstly, we describe flowering phenology, total anthophilous fauna and flower-visiting insect communities on respective plant species. Secondly, we examine the similarity of flower-visitor spectra among individual plant species. Thirdly, we compare flower-visiting patterns among dominant bee and syrphid fly species. Finally, we compare the anthophilous insect community with those at woodlands in various localities, and discuss characteristics of flower-insect relationships at wetlands.

## Study Site

Nakaikemi marsh, sometimes called as Kashimagari swamp, is located at 1 km east of Tsuruga city, Fukui Prefecture, Japan (35°39'N, 136°05'E). The marsh is surrounded by low hills covered with natural deciduous forests and planted *Cryptomeria* forests (Fig. 1). The marsh area is ca. 25 ha, and the altitude ranges from 41 to 48 m.

The marsh is thought to have been originally a reed (*Phragmites communis*) swamp accompanied by deciduous trees such as alders. About 350 years ago, a part of the marsh was reclaimed and utilized as traditional rice fields. In recent ten years, some of these rice fields were abandaned and are now on a way to return to original vegetation. Thus, the marsh is a mosaic of various types of vegetation; reed swamps, *Typha* and *Zizania* marshes, traditionally cultivated rice fields and abandoned rice fields on a way of succession (Plate 1, A-D). Among these vegetation, there are channels in which various aquatic plant species grow. The marsh has been known as the habitat of many endangered aquatic and marsh plant species such as *Marsilea quadrifolia* (Marsileaceae), *Salvinia natans* (Salviniaceae), *Nymphaea tetragona* (Nymphaeaceae), *Trapa incisa* (Trapaceae), *Menyanthes trifoliata* (Menyanthaceae), *Eusteralis yatabeana* (Labiatae), *Prenanthes tanakae* (Asteraceae), *Monochoria korsakowii* (Pontederiaceae) and *Iris laevigata* (Iridaceae) (Watanabe, 1989). Since construction of a highway at west edge of the marsh in 1990's, alien plant species started to invade some parts of the marsh. The marsh is now threatened by a plan of reclamation and construction of LNG storing plants.

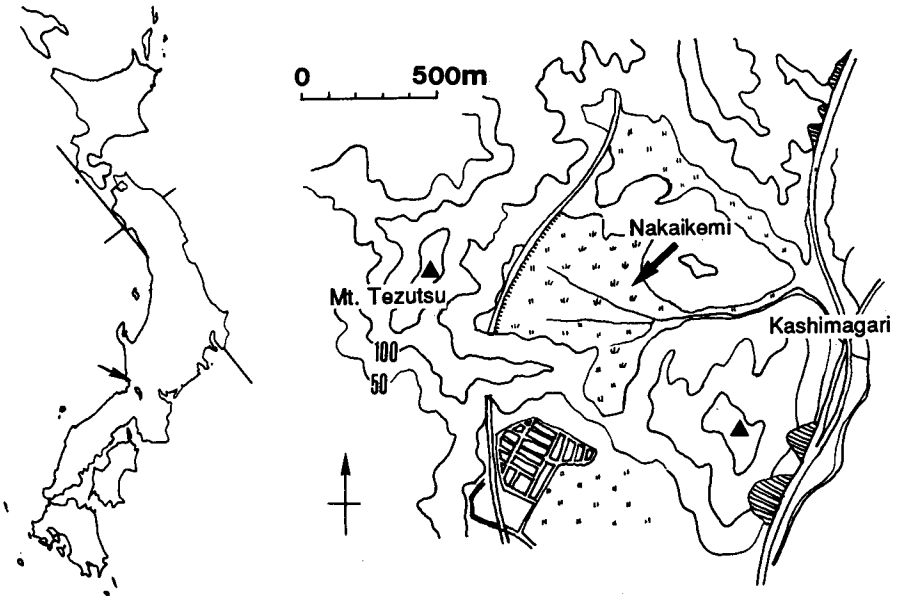


Fig. 1. The location of Nakaikemi marsh in Japan (left) and a map of the study area. Arrow shows Nakaikemi marsh.

## Methods

Surveys on flowering phenology and insect visits to flowers were conducted roughly monthly from mid April to mid October in 1994-95. Sampling dates and weather conditions on the days are shown in Table 1 (Sampling dates are coded in seasonal sequence). We started sampling of flower visiting insects at 0600-0900 and finished at 1200-1400. The sampling method of Kato et al. (1989) was adopted here. We walked on the fixed route in the marsh. When we found flowering plants, we netted insect visitors for about 10 minutes per one location. In the first 8 minutes we caught only insects flying around and visiting to flowers, avoiding harmful effects on flowers. In the last two minutes, we completely swept insects on the flowers.

All insect specimens were pinned and labeled with the complete census data (date, locality and flower species visited). They are classified and identified at species level although some were unidentified. All the specimens are kept in Biological Laboratory, Yoshida College, Kyoto University. Statistical analyses were made by the SAS package in the Data Processing Center, Kyoto University.

Table 1. Sampling dates with weather, number of observed flower species and number of insects collected on flowers.

| Code | Date | Weather | No. flower species | No. insects collected |
|---|---|---|---|---|
| 1 | April 17, 1994 | fine | 2 | 25 |
| 2 | May 14, 1994 | fine | 6 | 53 |
| 3 | June 1, 1995 | fine | 5 | 84 |
| 4 | June 22, 1994 | fine | 5 | 7 |
| 5 | June 30, 1995 | fine | 9 | 78 |
| 6 | July 17, 1994 | fine | 2 | 8 |
| 7 | July 28, 1994 | fine | 7 | 20 |
| 8 | August 5, 1995 | fine | 7 | 37 |
| 9 | August 16, 1994 | fine | 17 | 44 |
| 10 | September 17, 1994 | cloudy | 5 | 74 |
| 11 | September 28, 1995 | fine | 25 | 346 |
| 12 | October 2, 1994 | fine | 6 | 25 |
| 13 | October 9, 1994 | fine | 11 | 125 |

## Results

### 1. Studied plants

In Nakaikemi marsh, we studied flowering of 64 plant species (35 families, 55 genera); three shrubs, one climber, 17 annuals and 43 perennials (Table 2). These plant species consist of terrestrial (48.4 % of species), marsh (37.5 %), emerged (9.4 %), floating-leaved (3.1 %) and submerged plants (3.1 %). All plant species except naturalized *Bidens frondosa* and cultivated *Solanum melongena* and *Nymphaea marliacea* were indigenous, probably including some 'prehistoric-naturalized plants' (Maekawa, 1943). Most species were hermaphrodites, and three were monoecious (*Sagittaria trifolia, Hydrocharita dubia* and *Typha angustifolia*). *Lythrum anceps* showed tristyly, and *Monochoria korsakowii* and *M. vaginalis* showed enantiostyly.

Flower shape was classified into six categories; open flowers with radiate dish-bowl corollas (43.8 % of species), tubular (23.4 %), head (20.3 %), cup (6.3 %), spikelet (6.3 %) and apetalous flowers (1.6 %). Tubular flowers were subdivided into short-, middle- and long-tubed ones by the length of corolla tube; 0-5, 5-10, ≥ 10 mm, respectively. Four long-tubed flowers were *Prunella vulgaris, Weigela hortensis, Iris laevigata* and *Hosta albomarginata.* As to flower symmetry, 77.6 % were actinomorphic and 22.4 % were zygomorphic. Among various flower colors, white was dominant (26.1 %) and followed by purple (22.9 %), yellow (20.3 %), pink (11.4 %), green (9.4 %), blue (7.8 %), cream (1.6 %) and brown (1.6 %).

### 2. Flowering phenology

Flowering was observed from mid April to mid October (Fig. 2). The first bloomer was *Senecio pierotii* (Plate 1, C) and the last was *Prenanthes tanakae*; both were conspicuous perennial composites in the marsh and had brilliant yellow flowers. Other conspicuous flowers in the marsh were *Iris laevigata* in May (Plate 1, B), *Cardamine lyrata* in early June, *Hosta albomarginata* in July, *Persicaria* spp., *Lythrum anceps, Eusteralis yatabeana* (Plate 1, E),

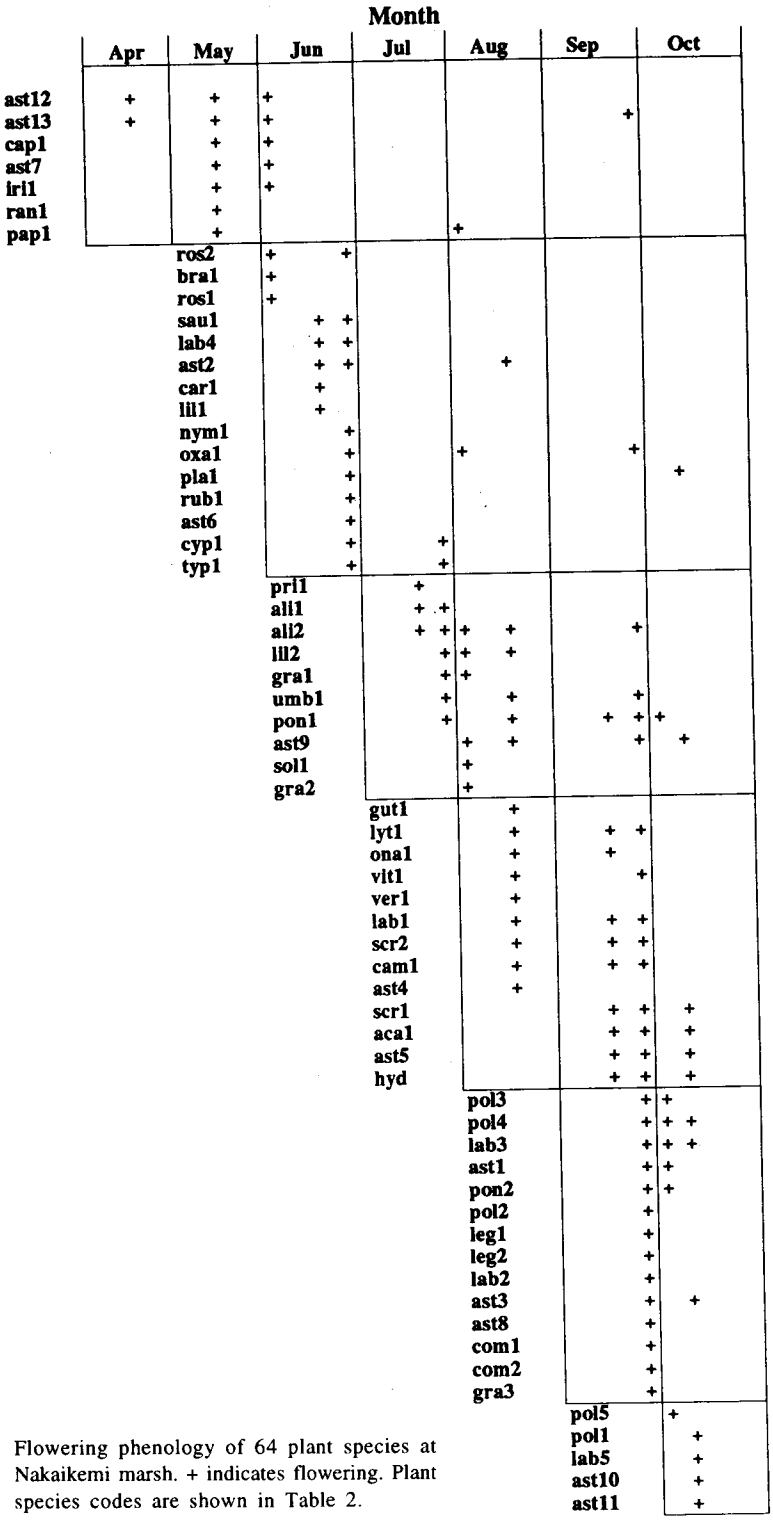


Fig. 2. Flowering phenology of 64 plant species at Nakaikemi marsh. + indicates flowering. Plant species codes are shown in Table 2.

Table 2. A list of 64 studied plant species in a order of Cronquist (1981), with species code, Japanese name, life form, habit, nativity, breeding system, flower shape, flower symmetry, flower color, number of insects collected on flowers, flower guild expected by a cluster analysis, and pollination guild of each plant species.

| Family | Code | Species | Japanese name | Life form[1] | Habit[2] | Nativity[3] | Breeding system[4] | Flower shape[5] | Flower symmetry[6] | Flower color[7] | No. of insects collected | Flower guild[8] | Pollination guild[9] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Saururaceae | saul | *Houttuynia cordata* | Dokudami | p | t | i | h | o | a | w | 1 | A | A |
| Nymphaeaceae | nym1 | *Nymphaea marliacea* | Suiren | p | f | c | h | o | a | w | 1 | B | B |
| Ranunculaceae | ran1 | *Ranunculus japonicus* | Kinpouge | p | t | i | h | o | a | y | 16 | B | B |
| Papaveraceae | pap1 | *Chelidonium majus* var. *asiaticum* | Kusanoou | p | t | i | h | o | a | y | 1 | A | A |
| Caryophyllaceae | car1 | *Stellaria media* | Hakobe | a | t | i | h | o | a | w | 1 | C5 | C5 |
| Polygonaceae | pol1 | *Persicaria conspicua* | Sakuratade | p | m | i | h | o | a | pk | 2 | C4 | C4 |
| | pol2 | *Persicaria nipponensis* | Yanonegusa | a | m | i | h | o | a | pk | 6 | C5 | C5 |
| | pol3 | *Persicaria sieboldi* | Akinounagitsukami | a | m | i | h | o | a | pk | 56 | C5 | C5 |
| | pol4 | *Persicaria thunbergii* | Mizosoba | a | m | i | h | o | a | pk | 102 | C1 | C1 |
| | pol5 | *Persicaria pubescens* | Bontokutade | a | m | i | h | o | a | pk | 3 | C5 | C5 |
| Guttiferae | gut1 | *Hypericum erectum* | Otogirisou | p | t | i | h | o | a | y | 1 | A | A |
| Brassicaceae | bra1 | *Cardamine lyrata* | Mizutagarasi | p | m | i | h | o | a | w | 26 | C1 | C1 |
| Primulaceae | pri1 | *Lysimachia fortunei* | Numatoranoo | p | m | i | h | o | a | w | 2 | C4 | C4 |
| Rosaceae | ros1 | *Potentilla egedei* var. *grandis* | Ohebiichigo | p | t | i | h | o | a | y | 17 | C5 | C5 |
| | ros2 | *Rosa multiflora* | Noibara | s | t | i | h | o | a | w | 4 | B | B |
| Leguminosae | leg1 | *Aeschynomene indica* | Kusanemu | a | m | i | h | t1 | z | c | 1 | B | B |
| | leg2 | *Lespedeza bicolor* | Yamahagi | p | t | i | h | t2 | z | pl | 2 | C4 | C4 |
| Lythraceae | lyt1 | *Lythrum anceps* | Misohagi | p | m | i | t | t1 | a | pl | 26 | C1 | C1 |
| Onagraceae | ona1 | *Ludwigia epilobioides* | Choujitade | a | m | i | h | o | a | y | 3 | A | A |
| Vitaceae | vit1 | *Ampelopsis brevipedunculata* var. *heterophylla* | Nobudou | c | t | i | h | o | a | g | 6 | C4 | C4 |
| Oxalidaceae | oxa1 | *Oxalis corniculata* | Katabami | p | t | i | h | o | a | y | 12 | B | B |
| Umbelliferae | umb1 | *Oenanthe javanica* | Seri | p | m | i | h | o | a | w | 11 | C1 | C1 |
| Solanaceae | sol1 | *Solanum melongena* | Nasu | a | t | c | h | o | a | bl | 2 | B | B |
| Verbenaceae | ver1 | *Clerodendrum trichotomum* | Kusagi | s | t | i | h | t2 | z | w+pl | 1 | C3 | C3 |
| Labiatae | lab1 | *Eusteralis yatabeana* | Mizutoranoo | p | m | i | h | t1 | z | pl | 54 | C1 | C1 |
| | lab2 | *Lycopus ramosissimus* var. *japonicus* | Koshirone | p | m | i | h | t1 | z | w | 11 | C4 | C4 |
| | lab3 | *Mosla dianthera* | Himejiso | p | m | i | h | t1 | z | w | 35 | C1 | C1 |
| | lab4 | *Prunella vulgaris* ssp. *asiatica* | Utsubogusa | p | t | i | h | t3 | z | pl | 23 | B | L |
| | lab5 | *Salvia japonica* | Akinotamurasou | p | t | i | h | t1 | z | pl | 5 | C1 | C1 |
| Plantaginaceae | pla1 | *Plantago asiatica* | Oobako | p | t | i | h | a | a | g | 1 | A | A |
| Scrophulariaceae | scr1 | *Limophila sessiliflora* | Kikumo | p | s | i | h | t1 | z | pl | 1 | A | A |
| | scr2 | *Lindernia procumbens* | Azena | a | m | i | h | t1 | z | w | 7 | A | A |
| Acanthaceae | aca1 | *Justicia procumbens* | Kitsunenomago | a | t | i | h | t2 | z | pl | 9 | B | B |
| Campanulaceae | cam1 | *Adenophora triphylla* var. *japonica* | Tsuriganeninjin | p | t | i | h | c | a | bl | 6 | C1 | C1 |
| Rubiaceae | rub1 | *Galium trifidum* var. *brevipedunculatum* | Hosobayotubamugura | p | m | i | h | o | a | w | 39 | C5 | C5 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Caprifoliaceae | capl | *Weigela hortensis* | Taniutsugi | s | t | i | h | t3 | a | pk | 3 | C3 | L |
| Asteraceae | astl | *Bidens frondosa* | Amerikasendangusa | a | t | n | h | h | a | y | 2 | C4 | C4 |
| | ast2 | *Cirsium japonicum* | Noazami | p | t | i | h | h | a | pl | 5 | B | B |
| | ast3 | *Cirsium sieboldii* | Kiseruazami | p | m | i | h | h | a | pl | 7 | C5 | L |
| | ast4 | *Eupatorium chinense* | Hiyodoribana | p | t | i | h | h | a | w | 5 | C4 | C4 |
| | ast5 | *Eupatorium lindleyanum* | Sawahiyodori | p | m | i | h | h | a | w | 73 | C5 | C5 |
| | ast6 | *Ixeris debilis* | Oojishibari | p | t | i | h | h | a | y | 3 | B | B |
| | ast7 | *Ixeris dentata* | Nigana | p | t | i | h | h | a | y | 4 | B | B |
| | ast8 | *Kalimeris pinnatifida* | Yuugagiku | p | t | i | h | h | a | pl+y | 30 | C5 | C5 |
| | ast9 | *Kalimeris yomena* | Yomena | p | t | i | h | h | a | pl+y | 6 | C4 | C4 |
| | astl0 | *Lactuca indica* | Akinonogeshi | a | t | i | h | h | a | y | 2 | A | A |
| | astl1 | *Prenanthes tanakae* | Oonigana | p | m | i | h | h | a | y | 40 | C5 | C5 |
| | astl2 | *Senecio pierotii* | Sawaoguruma | p | m | i | h | h | a | y | 45 | C1 | C1 |
| | astl3 | *Taraxacum japonicum* | Kansaitanpopo | p | t | i | h | h | a | y | 15 | B | B |
| Alismataceae | alil | *Alisma canaliculatum* | Heraomodaka | p | e | i | h | o | a | w | 8 | C1 | C1 |
| | ali2 | *Sagittaria trifolia* | Omodaka | p | e | i | m | o | a | w | 37 | C1 | C1 |
| Hydrocharitaceae | hydl | *Hydrocharis dubia* | Tochikagami | p | f | i | m | o | a | w | 21 | C5 | C5 |
| Commelinaceae | coml | *Commelina communis* | Tsuyukusa | a | t | i | h | o | z | bl | 1 | A | A |
| | com2 | *Murdannia keisak* | Ibokusa | a | m | i | h | o | a | pk | 2 | A | A |
| Gramineae | gral | *Isachne globosa* | Chigozasa | p | m | i | h | o | a | g | 10 | A | W |
| | gra2 | *Leesia japonica* | Ashikaki | p | e | i | h | s | a | g | 18 | A | W |
| | gra3 | *Phragmites communis* | Yoshi | p | e | i | h | s | a | g | 11 | C5 | W |
| Cyperaceae | cypl | *Scirpus triqueter* | Sankakui | p | e | i | h | s | a | g | 10 | A | W |
| Typhaceae | typl | *Typha angustifolia* | Himegama | p | e | i | m | s | a | br | 2 | C2 | W |
| Pontederiaceae | ponl | *Monochoria korsakowii* | Mizuaoi | a | e | i | e | c | z | bl | 35 | B | B |
| | pon2 | *Monochoria vaginalis* | Konagi | a | e | i | e | c | z | bl | 1 | B | B |
| Iridaceae | iril | *Iris laevigata* | Kakitsubata | p | m | i | h | t3 | z | pl | 39 | B | L |
| Liliaceae | lill | *Alium grayi* | Nobiru | p | t | i | h | o | a | pk | 1 | B | B |
| | lil2 | *Hosta albomarginata* | Kobagiboushi | p | m | i | h | t3 | a | pl | 6 | B | L |
| Total | | | | | | | | | | | 936 | | |

[1] a, annual; c, climber; p, perennial; s, shrub.
[2] e, emerged plants; f, floating-leaved plants; m, marsh plants; s, submerged plants; t, terrestrial plants.
[3] c, cultivated; i, indigenous; n, naturalized.
[4] e, enantiostyle hermaphrodite; h, hermaphrodite; m, monoecious; t, tristyle hermaphrodite.
[5] a, apetalous; c, cup-shaped; h, head; o, open (disk-like); s, spikelet; t1, short-tubed (<5 mm); t2, middle-tubed (5 ≤ tube < 10 mm); t3, long-tubed (≥ 10 mm)
[6] a, actinomorphic; z, zygomorphic. Heads are treated as actinomorphic.
[7] Color of petal, sepal or bract: bl, blue; br, brown; c, cream; g, green; pk, pink; pl, purple; w, white; y, yellow.
[8] characterized by: A, syrphid flies; B, small or large bees; C1, a mixture of various groups of insects; C2, beetles; C3, lepidopterans; C4, wasps or middle-sized bees; C5, caryptrate or other flies.
[9] in addition to flower guild: W, anemophilous; L, pollinated by long-tongued bumblebees.

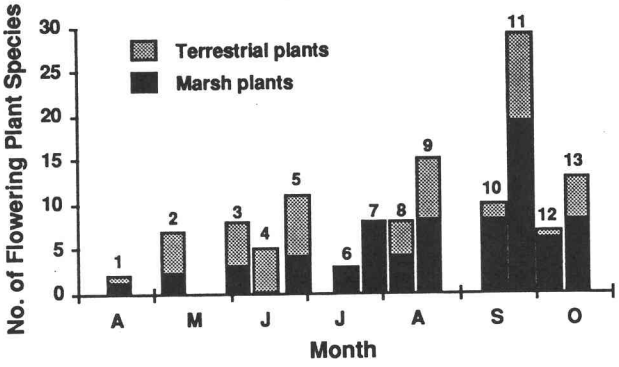


Fig. 3. Seasonal change in the number of plant species blooming at each sampling date. The number above the column denote sampling codes shown in Table 1.

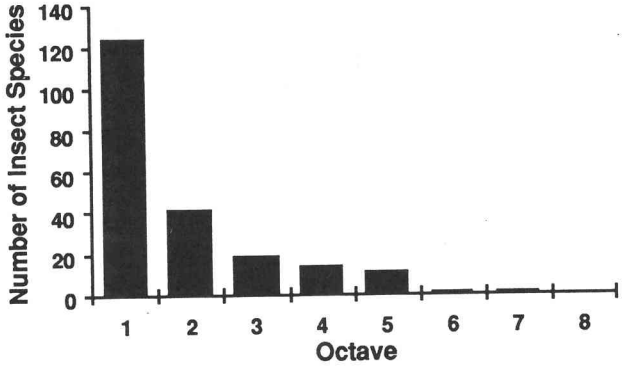


Fig. 4. The number of insect species plotted in the Preston's octave.

*Eupatorium lindleyanum* (Plate 1, F) and *Monochoria korsakowii* (Plate 1, H) in September. In channels, *Sagittaria trifolia* flowered from July to September and *Hydrocharis dubia* flowered from September to October (Plate 1, K). The number of aquatic and marsh plant species flowering at each sampling date increased from April to late September, and decreased in October (Fig. 3).

### 3. **Flower-visiting insect community**

#### 3-1. *Faunal makeup*

A total of 936 individuals of 216 species in seven insect orders were collected (Table 3). In Fig. 4, the number of species is plotted in octave of abundance, which is the logarithm of the number of individuals to base 2 (Preston, 1962; May, 1975). The curve is regarded as the truncated log-normal distribution of species abundance. When the data is applied to Fisher's logarithmic series (Fisher *et al.*, 1943), the Fisher's index of diversity, $\alpha$, was estimated to be 88.

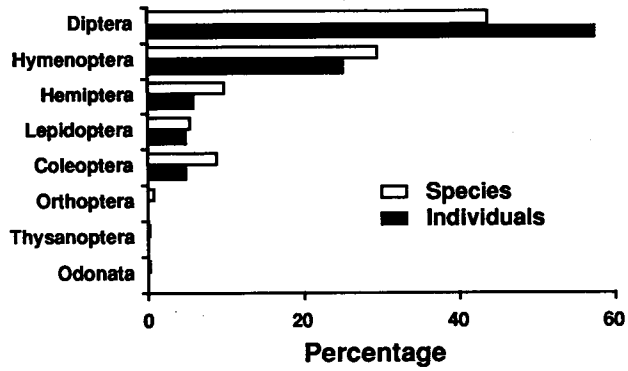


Fig. 5. The percentages of numbers of insect species (open bar) and individuals (solid bar) in orders.

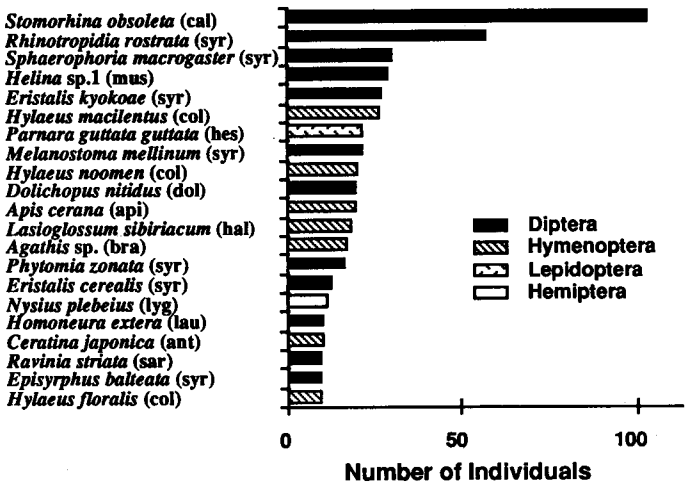


Fig. 6. Abundance ranking of visitor species at Nakaikemi marsh. See Table 3 for family codes in parentheses.

The relative abundance of individuals was greatest in Diptera (57.2 %), followed by Hymenoptera (26.1 %), Hemiptera (6.1 %), Lepidoptera (5.1 %) and Coleoptera (4.9 %, Fig. 5). The relative number of species was also greatest in Diptera (44.0 %), followed by Hymenoptera (29.7 %), Hemiptera (10.0 %), Coleoptera (9.1 %) and Lepidoptera (5.7 %). The mean number of individuals per species was highest in Diptera (5.8), followed by Lepidoptera (4.0), Hymenoptera (3.9), Hemiptera (2.7) and Coleoptera (2.4). The ranking of individual number of each species is shown in Fig. 6. Five most abundant species were dipterans.

Table 3. A list of insect families collected on flowers at Nakaikemi with numbers and percentages of species and individuals.

| Order | Family | Code | Larval feeding habit[1] | Adult feeding habit[1] | Larval habitat[2] | Species | | Individuals | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | No. | % | No. | % |
| Odonata | Agrionidae | Agr | pr | pr | a | 1 | 0.46 | 1 | 0.11 |
| Orthoptera | Tettigoniidae | Tet | o | o | t | 1 | 0.46 | 2 | 0.22 |
| | Gryllidae | Gry | o | o | t | 1 | 0.46 | 1 | 0.11 |
| Thysanoptera | Phlaeothripidae | Phl | ph | ph | t | 1 | 0.46 | 2 | 0.22 |
| Hemiptera | Pentatomidae | Pen | ph | ph | t | 3 | 1.39 | 7 | 0.75 |
| | Cydnidae | Cyd | ph | ph | t | 1 | 0.46 | 1 | 0.11 |
| | Plataspidae | Pla | ph | ph | t | 1 | 0.46 | 1 | 0.11 |
| | Lygaeidae | Lyg | ph | ph | t | 4 | 1.85 | 19 | 2.04 |
| | Miridae | Mir | pr | pr | t | 2 | 0.93 | 6 | 0.65 |
| | Rhopalidae | Rho | pr | pr | t | 1 | 0.46 | 1 | 0.11 |
| | Reduviidae | Red | pr | pr | t | 1 | 0.46 | 1 | 0.11 |
| | Nabidae | Nab | pr | pr | t | 1 | 0.46 | 1 | 0.11 |
| | Hydrometridae | Hyd | ph | ph | t | 1 | 0.46 | 1 | 0.11 |
| | Cercopidae | Cer | ph | ph | t | 1 | 0.46 | 9 | 0.97 |
| | Deltocephalidae | Del | ph | ph | t | 3 | 1.39 | 7 | 0.75 |
| | Dictyopharidae | Dic | ph | ph | t | 1 | 0.46 | 1 | 0.11 |
| Coleoptera | Scarabaeidae | Sca | ph | p | t | 1 | 0.46 | 6 | 0.65 |
| | Helodidae | Hel | ph | pr | t | 1 | 0.46 | 4 | 0.43 |
| | Cantharidae | Can | pr | pr | t | 1 | 0.46 | 3 | 0.32 |
| | Coccinellidae | Coc | pr | pr | t | 3 | 1.39 | 3 | 0.32 |
| | Melyridae | Mel | ph | p | t | 1 | 0.46 | 1 | 0.11 |
| | Lathridiidae | Lat | ph | p | t | 2 | 0.93 | 2 | 0.22 |
| | Languriidae | Lan | ph | p | t | 1 | 0.46 | 2 | 0.22 |
| | Chrysomelidae | Chr | ph | ph,p | t | 5 | 2.31 | 19 | 2.04 |
| | Attelabidae | Att | ph | p | t | 1 | 0.46 | 1 | 0.11 |
| | Curculionidae | Cur | ph | p | t | 3 | 1.39 | 5 | 0.54 |
| Diptera | Tipulidae | Tip | s | n | a,t | 3 | 1.39 | 3 | 0.32 |
| | Sciaridae | Sci | s | n | t | 2 | 0.93 | 4 | 0.43 |
| | Chironomidae | Chi | s | n | a | 4 | 1.85 | 9 | 0.97 |
| | Ceratopogonidae | Cer | pr,s | n | a | 1 | 0.46 | 2 | 0.22 |
| | Empididae | Emp | pr | n | t | 1 | 0.46 | 3 | 0.32 |
| | Stratiomyidae | Str | p | n | a | 1 | 0.46 | 1 | 0.11 |
| | Syrphidae | Syr | pr,s,ph | n,p | a,t | 22 | 10.19 | 231 | 24.52 |
| | Pipunculidae | Pip | ps | n | t | 1 | 0.46 | 2 | 0.22 |
| | Phoridae | Pho | ps,s | n | t | 2 | 0.93 | 2 | 0.22 |
| | Sciomyzidae | Scm | pr | n | a | 2 | 0.93 | 5 | 0.54 |
| | Dolichopodidae | Dol | pr | n | a | 3 | 1.39 | 24 | 2.58 |
| | Lauxaniidae | Lau | s | n | t | 3 | 1.39 | 13 | 1.40 |
| | Ephydridae | Eph | s,ph | n | a | 8 | 3.70 | 18 | 1.94 |
| | Sphaeroceridae | Sph | s | n | t | 1 | 0.46 | 2 | 0.22 |
| | Canaceidae | Cnc | s | n | a | 1 | 0.46 | 2 | 0.22 |
| | Drosophilidae | Dro | ph | n | t | 2 | 0.93 | 3 | 0.32 |
| | Anthomyiidae | Ant | ph,s | n | t | 2 | 0.93 | 3 | 0.32 |
| | Muscidae | Mus | s | n,p | t,a | 20 | 9.26 | 66 | 7.10 |
| | Sarcophagidae | Sar | s | n,p | t | 1 | 0.46 | 10 | 1.08 |
| | Calliphoridae | Cal | s | n,p | t,a | 7 | 3.24 | 119 | 12.80 |
| | Tachinidae | Tac | ps | n | t | 8 | 3.70 | 12 | 1.29 |
| Lepidoptera | Pyralidae | Pyr | ph | n | t | 2 | 0.93 | 10 | 1.08 |
| | Hesperiidae | Hes | ph | n | t | 4 | 1.85 | 28 | 3.01 |
| | Papilionidae | Pap | ph | n | t | 1 | 0.46 | 3 | 0.32 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Pieridae | Pie | ph | n | t | 1 | 0.46 | 1 | 0.11 |
| | Lycaenidae | Lyc | ph | n | t | 2 | 0.93 | 2 | 0.22 |
| | Nymphalidae | Nym | ph | n | t | 1 | 0.46 | 3 | 0.32 |
| | Satyridae | Sat | ph | n | t | 1 | 0.46 | 1 | 0.11 |
| Hymenoptera | Tenthredinidae | Ten | ph | n,pr | t | 3 | 1.39 | 4 | 0.43 |
| | Argidae | Arg | ph | n | t | 1 | 0.46 | 1 | 0.11 |
| | Ichneumonidae | Ich | ps | n | t | 6 | 2.78 | 7 | 0.75 |
| | Braconidae | Bra | ps | n | t | 9 | 4.17 | 28 | 3.01 |
| | Eulophidae | Eul | ps | n | t | 1 | 0.46 | 1 | 0.11 |
| | Chalcididae | Cha | ps | n | t | 2 | 0.93 | 2 | 0.22 |
| | Encyrtidae | Enc | ps | n | t | 1 | 0.46 | 3 | 0.32 |
| | Scolitidae | Sco | r | n | t | 1 | 0.46 | 1 | 0.11 |
| | Formicidae | For | r | n,pr | t | 1 | 0.46 | 6 | 0.65 |
| | Eumenidae | Eum | r | n,pr | t | 4 | 1.85 | 8 | 0.86 |
| | Vespidae | Ves | r | n,pr | t | 4 | 1.85 | 9 | 0.97 |
| | Pompilidae | Pom | r | n,pr | t | 2 | 0.93 | 2 | 0.22 |
| | Sphecidae | Sph | r | n,pr | t | 2 | 0.93 | 2 | 0.22 |
| | Colletidae | Col | n,pr | n | t | 4 | 1.85 | 61 | 6.56 |
| | Halictidae | Hal | n,pr | n | t | 9 | 4.17 | 40 | 4.30 |
| | Andrenidae | And | n,pr | n | t | 3 | 1.39 | 8 | 0.86 |
| | Megachilidae | Meg | n,pr | n | t | 3 | 1.39 | 11 | 1.18 |
| | Anthophoridae | Ant | n,pr | n | t | 6 | 2.78 | 22 | 2.37 |
| | Apidae | Api | n,pr | n | t | 3 | 1.39 | 28 | 3.01 |
| Total | | | | | | 215 | | 936 | |

[1] n, nectarivorous; o, omnivorous; p, pollenivorous; ph, phytophagous; pr, predatory; ps, parasitic; r, reared with hunted prey; s, saprophagous.
[2] a, aquatic or subaquatic; t, terrestrial.

### 3-2. *Hemiptera*

The most abundant family was Lygaeidae (33.3 %), followed by Cercopidae (15.8 %), Pentatomidae (12.8 %), Deltocephalidae (12.3 %) and Miridae (10.5 %). Two dominant lygaeid species were *Nysius plebeius* (21.0 %) and *Tropidothorax cruciger* (12.3 %), both of which were found sucking flowers of Asteriaceae and other plant families.

### 3-3. *Coleoptera*

Four dominant families were Chrysomelidae (41.3 %), Scarabaeidae (13.0 %), Curculionidae (10.8 %) and Helodidae (8.7 %). Abundant coleopterous species were *Calomicrus* sp. (Chrysomelidae, 9) and *Oxycetonia jucunda* (Scarabaeidae, 6) (Plate 1, F). *Cryptophilus* sp. (Languriidae) was only visitors to flowers of *Typha angustifolia* (Typhaceae), and was also reared up from its sampled female spikes.

### 3-4. *Diptera*

The most abundant groups were hoverflies (42.8 % in Diptera) and Calyptrate flies (39.3 %). In Syrphidae, 22 species of 17 genera, eight tribes and three subfamilies were recorded (Table 4). Larval feeding types of the hoverflies could be grouped following Ferrar (1987), Owen and Gilbert (1989) and Rotheray (1993): predators (9 genera, 12 species, 90 individuals, 38.8 % in Syrphidae), aquatic or subaquatic saprophages (6 gen., 7 spp., 136 individuals, 58.6 %), herbivores

Table 4. A list of syrphid fly species collected on flowers, with their larval feeding habits, numbers of individuals collected in each month, and sex ratios.

| Subfamily / Tribe | Species | Larval feeding habit[1] | Month | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | female | male | Total |
| Syrphinae | | | | | | | | | | | | |
| Melastomatini | *Melanostoma mellinum* | p | 0 | 0 | 0 | 1 | 21 | 0 | 0 | 16 | 6 | 22 |
| | *Melanostoma scalare* | p | 1 | 0 | 2 | 0 | 0 | 1 | 1 | 5 | 0 | 5 |
| | *Platycheirus pennipes* | p | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 2 | 6 | 8 |
| Paragini | *Paragus quadrifasciatus* | p | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 |
| | *Paragus jozanus* | p | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 2 |
| | *Paragus kaemorrhous* | p | 0 | 0 | 0 | 0 | 2 | 2 | 1 | 3 | 2 | 5 |
| Syrphini | *Betasyrphus serarius* | p | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 |
| | *Episyrphus balteata* | p | 0 | 0 | 1 | 0 | 4 | 3 | 2 | 9 | 1 | 10 |
| | *Epistrophe* sp. | p | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| | *Allograpta javana* | p | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 1 | 2 |
| | *Sphaerophoria macrogaster* | p | 0 | 2 | 10 | 2 | 1 | 17 | 0 | 2 | 29 | 31 |
| Milesiinae | | | | | | | | | | | | |
| Cheilosiini | *Cheilosia* sp.1 | h | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 3 |
| | *Cheilosia* sp.2 | h | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Eristalini | *Eristalinus viridis* | s | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 4 | 0 | 4 |
| | *Eristalis cerealis* | s | 3 | 0 | 0 | 0 | 0 | 9 | 1 | 10 | 3 | 13 |
| | *Eristalis kyokoae* | s | 1 | 0 | 0 | 0 | 0 | 10 | 17 | 19 | 9 | 28 |
| | *Helophilus virgatus* | s | 3 | 0 | 0 | 0 | 0 | 0 | 6 | 7 | 2 | 9 |
| | *Mesembrius flaviceps* | s | 0 | 4 | 0 | 1 | 0 | 2 | 0 | 3 | 4 | 7 |
| | *Phytomia zonata* | s | 0 | 0 | 0 | 0 | 0 | 13 | 4 | 7 | 10 | 17 |
| Milesiini | *Rhinotropidia rostrata* | s | 0 | 2 | 9 | 1 | 14 | 29 | 3 | 32 | 26 | 58 |
| Pipizini | *Pipiza lugubrius* | p | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 2 |
| Microdontinae | | | | | | | | | | | | |
| | *Microdon japonicus* | a | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 |
| Total | | | 9 | 11 | 30 | 6 | 42 | 94 | 40 | 130 | 101 | 231 |

[1] a, ant nest inquiline; h, herbivore; p, predator of aphids and other invertebrates; s, aquatic or subaquatic saprophage.

(1 gen., 2 spp., 4 individuals, 1.7 %) and ant nest inqualine (1 gen., 1 sp., 1 individual, 0.5 %).

In Calyptrata, Calliphoridae was most abundant (22.2 %), followed by Muscidae (12.3 %), Tachinidae (2.2 %), Sarcophagidae (1.9 %). Dominant muscid genera, *Helina, Limnophora* (Plate 1, J) and *Lispe*, are saprophages in mesic, subaquatic or aquatic habitats (Ferrar, 1987). The calliphorid fly, *Stomorhina obsoleta*, was the most abundant species in Diptera, and the muscid fly, *Helina* sp. 1, was the second (Fig. 6). Abundant families other than Calyptrata were Dolichopodidae (4.5 % in Diptera), Ephydridae (3.4 %) and Lauxaniidae (2.4 %); larvae of the former two families are aquatic (Table 3).

3-5. *Lepidoptera*

The most abundant family was Hesperiidae (58.3 %), followed by Pyralidae (20.8 %), Papilionidae (6.3 %) and Nymphalidae (6.3 %). A grass-feeding skipper, *Parnara guttata guttata*, was the most abundant species (45.8 %), and a polyphagous pyralid, *Hymerria recurvalis*, was the second (16.7 %).

3-6. *Hymenoptera*

The most abundant superfamily of Hymenoptera was Apoidea (69.3 %), followed by Ichneumonoidea (14.3 %) and Vespoidea (7.0 %). Rarity of Sphecoidea nesting under ground was characteristic. In Apoidea, 28 species and 169 individuals were collected, and Colletidae was most abundant (36.1 %), followed by Halictidae (23.7 %), Apidae (16.5 %), Anthophoridae (12.4 %), Megachilidae (6.5 %) and Andrenidae (4.7 %) (Table 5). The most abundant bee species was *Hylaeus macilentus*, followed by *H. noomen, Apis cerana* and *Lasioglossum sibiriacum* (Fig. 6). *Hylaeus macilentus* (Plate 1, I) is a minute rare species which has been

Table 5. A list of bee genera at Nakaikemi marsh, with size class, nest site and relative abundance of them.

| Family | Subfamily | Genus | Size class[1] | Nest site[2] | No. of species | No. of individuals |
|---|---|---|---|---|---|---|
| Colletidae | Hylaeinae | *Hylaeus* | s | s | 3 | 58 |
| | Colletinae | *Colletes* | m | g | 1 | 3 |
| Halictidae | Halictinae | *Lasioglossum* | s | g | 9 | 40 |
| Andrenidae | Andreninae | *Andrena* | s | g | 3 | 8 |
| Megachilidae | Megachilinae | *Megachile* | m | s | 2 | 10 |
| | | *Osmia* | m | s | 1 | 1 |
| Anthophoridae | Nomadinae | *Nomada* | s | p | 2 | 3 |
| | Xylocopoinae | *Ceratina* | s | s | 3 | 15 |
| | | *Xylocopa* | l | w | 1 | 3 |
| Apidae | Bombinae | *Bombus* | l | g | 2 | 8 |
| | Apinae | *Apis* | m | h | 1 | 20 |
| Total | | | | | 28 | 169 |

[1] l, large; m, middle-sized; s, small.

[2] g, underground; h, tree hollows; p, cleptoparasitic; s, preexisting cavities such as stem hollows or beetle burrows; w, tree burrows bored by itself.

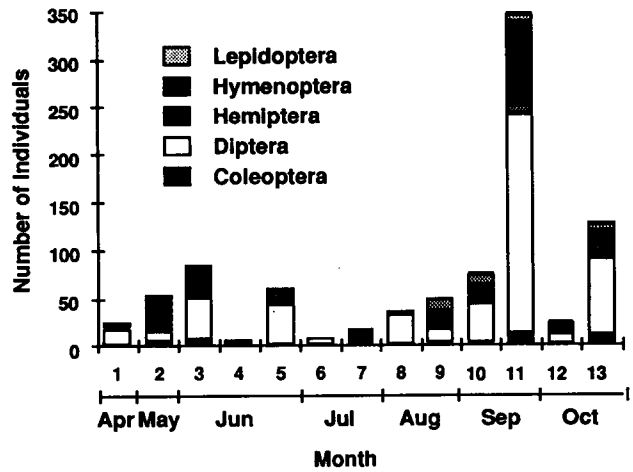


Fig. 7. Seasonal change in the number of insects collected on flowers at each sampling date. Insects are sorted by orders.

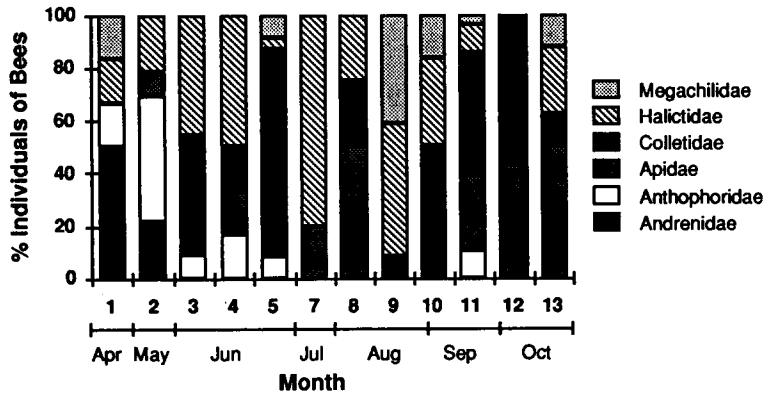


Fig. 8. Seasonal change in the proportion of six bee families collected on flowers at Nakaikemi marsh.

recorded from only three localities in Hokkaido and Honshu (Ikudome, 1989). *Bombus* was uncommon in the marsh (4.7 % of bees). All collected bumblebees except one male of *B. hypocrita* were workers of long-tongued *B. diversus*. In the genus *Apis*, only *A. cerana* was recorded mainly in autumn. A large proportion of bees were aboveground nest makers (65.1 %), and 34.9 % were underground nest makers.

### 4. Phenology of flower visitors

The number of collected insects per census had two peaks in early June and late September (Fig. 7). The samples except in May and late July were dominated by dipterans. Dominant hoverfly species were active throughout the flowering season (Table 4). In contrast, the most dominant calliphorid fly, *Stomorhina obsoleta*, was abundant only in autumn. Anthophilous fauna of Hymenoptera was dominated by Colletidae, Halictidae or Apidae except in April and May when Andrenidae was abundant (Fig. 8).

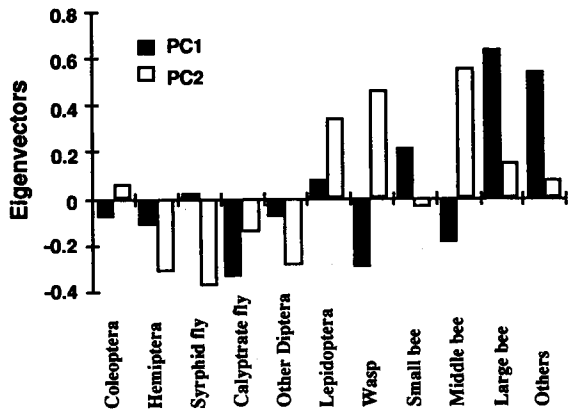


Fig. 9. A result of principal component analysis of flower-visitor spectra of 64 plant species. Eigenvectors of the first two principal components calculated shown against visitor groups.

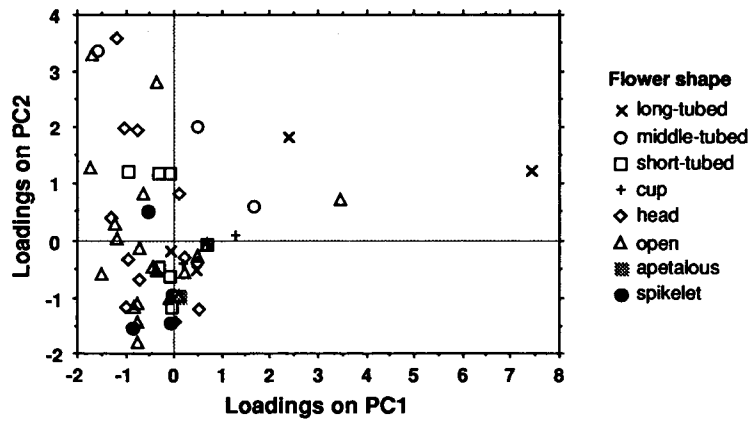


Fig. 10. Scattering graphs obtained by a principal component analysis of flower-visitor spectra of 64 plant species. Two axes refer to the loadings on the first and the second principal components. Plots refer to plant species discriminated by flower shape. Eigenvectors of the two axes are shown in Fig. 9.

## 5. **Anthophilous insect communities on individual plant species**

### 5.1. *Principal component analysis*

Anthophilous insect community on each plant species varied greatly among plant species (Appendix 1). In order to search for trends explaining the variance in flower-visiting insect communities, a principal component analysis was made. In this analysis, insects were classified into eleven taxonomic groups; coleopterans, hemipterans, syrphid flies, calyptrate flies, other dipterans, lepidopterans, wasps, small bees, middle-sized bees, large bees (bees are categorized as shown in Table 4) and other orders. The percentages of these eleven groups in individual number were defined as a flower-visitor spectrum of each plant species.

The flower visitor spectra of 64 plant species were used as statistics of the principal component analysis. Loadings of 1st and 2nd principal components are shown in Fig. 9. The

major trend involved alternation of dominant insect groups between large bees and calyptrate flies (the first principal component, PC1, being 15.6 % of the total variance). The second factor corresponds to dominance of wasps and middle-sized bees over syrphid flies (PC2, 14.4 %). It is interesting that wasps and middle-sized bees had similar loading patterns. The third factor was mainly related to alternation of dominant insect groups between calyptrate flies and syrphid flies (PC3, 13.3 %). The cumulative percentages of eigenvalues of the first three principal components were 43.3 %, suggesting that there are additional factors contributing to the total variance. Scattering plots in Fig. 10 show that there is no clear trend unique to flower shape with the exception of the larger PC1 of long-tubed flowers and the larger PC2 of middle-tubed flowers. In other words, long-tubed and middle-tubed flowers had tendency to be visited by large and middle-sized bees, respectively.

5.2. *Cluster analysis*

The flower-visitor spectra were also applied for cluster analysis; statistics were the percentages of individuals in respective insect groups. A dendrogram derived from the cluster analysis is shown in Fig. 11. At semi-partial $r^2 = 0.2$, 64 plant species were divided into three clusters. Cluster A was separated from others by predominance of syrphid flies, and was composed of 13 species of Saururaceae (1 sp.), Papaveraceae (1 sp.), Guttiferae (1 sp.), Onagraceae (1 sp.), Plantaginaceae (1 sp.), Scrophulariaceae (2 spp.), Asteraceae (1 sp.), Commelinaceae (2 spp.) and Graminae (3 spp.). A submerged aquatic perennial, *Limnophila sessiliflora*, flowered after water level went down in September, and was visited exclusively by a small syrphid fly, *Sphaerophoria macrogaster* (Plate 1, J).

Cluster B was separated from others by predominance of small or large bees, and was composed of 18 plant species of Nymphaeaceae (1 sp.), Ranunculaceae (1 sp.), Caryophyllaceae (1 sp.), Rosaceae (1 sp.), Leguminosae (1 sp.), Oxalidaceae (1 sp.), Solanaceae (1 sp.), Labiatae (1 sp.), Acanthaceae (1 sp.), Asteraceae (4 spp.), Pontederiaceae (2 spp.), Iridaceae (1 sp.) and Liliaceae (2 spp.). For example, *Iris laevigata* was frequently visited by colletid small bees (Plate 1, I).

The last cluster C was sub-divided into five clusters (Cluster C1-C5) at semi-partial $r^2 = 0.03$. Cluster C1 was characterized by a mixture of various insect groups, and was composed of 11 species of Polygonaceae (1 sp.), Brassicaceae (1 sp.), Lythraceae (1 sp.), Umbelliferae (1 sp.), Labiatae (3 spp.), Campanulaceae (1 sp.), Asteraceae (1 sp.) and Alismataceae (2 spp.). Cluster C2 composed of only *Typha angustifolia* (Typhaceae) and was characterized by dominance of Coleoptera. Cluster C3 was composed of *Clerodendrum trichotomum* (Verbenaceae) and *Weigela hortensis* (Caprifoliaceae), and was characterized by dominance of Lepidoptera. Cluster C4 was separated by dominance of wasps and middle-sized bees, and was composed of 8 plant species of Polygonaceae (1 sp.), Leguminosae (1 sp.), Primulaceae (1 sp.), Vitaceae (1 sp.), Labiatae (1 sp.), Asteraceae (3 spp.). For example, *Ampelopsis brevipedunculata* (Vitaceae) and *Lycopus ramosissimus* were uniquely visited by *Eumenes* spp. (Eumenidae) and *Polistes chinensis* (Vespidae), respectively. Naturalized *Bidens frondosa* was visited only by *Apis cerana*. Cluster C5 was characterized by high proportions of calyptrate flies and other dipterans, and was composed of 11 species of Polygonaceae (3 spp.), Rosaceae (1 sp.), Rubiaceae (1 sp.), Asteraceae

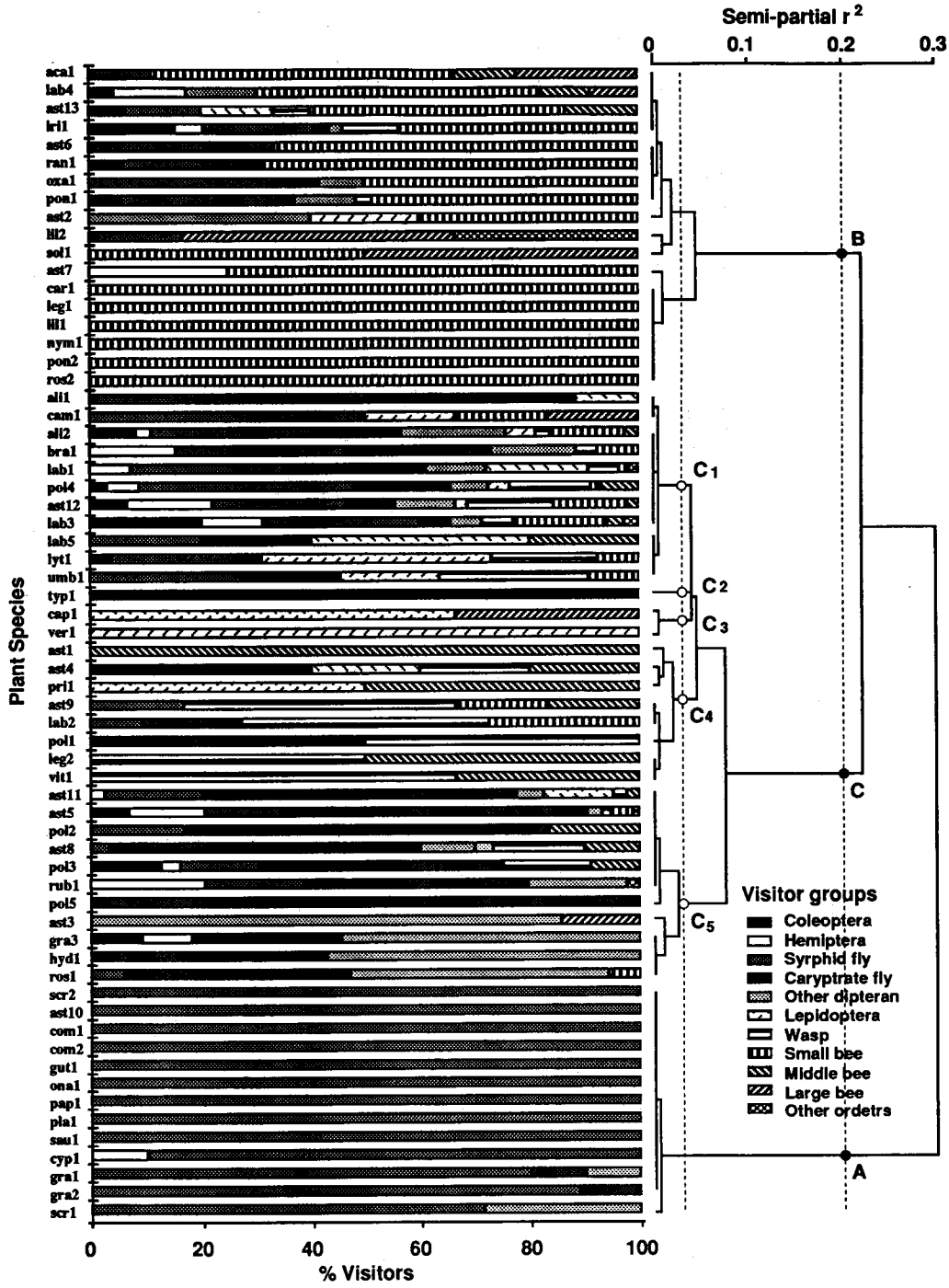


Fig. 11. Flower-visitor spectra (sorted by visitor group) of 64 plant species and dendrogram (right) derived from cluster analysis on the flower spectra. Plant species codes are shown in Table 2. Three clusters (A, B and C) were detected at semi-partial $r^2 = 0.2$. The cluster C was subdivided into five clusters at semi-partial $r^2 = 0.03$.

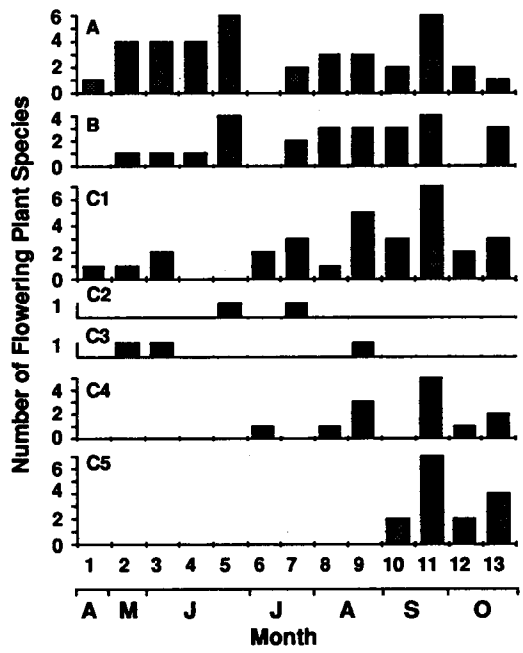


Fig. 12. Seasonal changes in the number of plant species blooming at each sampling date for each flower guild detected by a cluster analysis in Fig. 11.

(4 spp.), Hydrocharitaceae (1 sp.) and Gramineae (1 sp.). A floating leaved aquatic plant, *Hydrocharis dubia*, had flowers just above the water surface, and was frequently visited by muscid flies (Plate 1, K), larvae of which are aquatic or subaquatic saprophages. These seven clusters can be regarded as flower guilds based on flower-visits by insect groups.

Flowering phenology was compared among these flower guilds (Fig. 12). Flowers in three guilds (A, B, C1) bloomed sequentially from mid April to mid October. Wasp/middle-sized bee flowers (C4) were summer and autumn bloomers, and calyptrate fly flowers (C5) were autumn bloomers.

5.3. *Flower guilds and pollination guilds*

In order to detect the factors determining flower guilds, effects of flower shape and flower color on flower guilds were examined. We compared the frequencies of plant species in each flower guild among flower shape, and examined homogeneity of these frequencies by chi-square tests (Table 6). There was no significant correlation between flower shape and flower guilds. Long-tubed flowers were likely to be bee flowers whereas this correlation was not significant ($\chi^2 = 0.29$, $P > 0.05$). As for flower symmetry, zygomorphic flowers had tendency to be bee flowers (8 spp. of 14 zygomorphic species and 18 spp. of 50 actinomorphic ones were bee flowers), whereas this correlation was not significant ($\chi^2 = 2.03$, $P > 0.05$).

Table 7 shows the relationship between flower colors and flower guilds. Significant correlations were detected between blue color and bee flowers ($\chi^2 = 7.22$, $P < 0.01$).

Table 6. Numbers of plant species sorted by flower guild and flower shape.

| Flower shape | Flower guild | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | A | B | C1 | C2 | C3 | C4 | C5 | |
| apetalous | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| cup-shaped | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 3 |
| head | 1 | 4 | 1 | 0 | 0 | 3 | 4 | 13 |
| open | 7 | 7 | 5 | 0 | 0 | 3 | 6 | 28 |
| spikelet | 2 | 0 | 0 | 1 | 0 | 0 | 1 | 4 |
| short-tubed | 2 | 1 | 4 | 0 | 0 | 1 | 0 | 8 |
| middle-tubed | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 3 |
| long-tubed | 0 | 3 | 0 | 0 | 1 | 0 | 0 | 4 |
| Total | 13 | 18 | 11 | 1 | 2 | 8 | 11 | 64 |

Table 7. Numbers of plant species sorted by flower guild and flower color.

| Color | Flower guild | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | A | B | C1 | C2 | C3 | C4 | C5 | |
| blue | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 5 |
| brown | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| cream | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| green | 4 | 0 | 0 | 0 | 0 | 1 | 1 | 6 |
| pink | 1 | 1 | 1 | 0 | 1 | 0 | 3 | 7 |
| purple | 1 | 4 | 4 | 0 | 1 | 1 | 1 | 12 |
| purple & yellow | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 |
| white | 1 | 3 | 5 | 0 | 0 | 4 | 4 | 17 |
| yellow | 5 | 5 | 1 | 0 | 0 | 1 | 1 | 13 |
| Total | 13 | 18 | 11 | 1 | 2 | 8 | 11 | 64 |

As for breeding systems, monoecious entomophilous species, *Sagittaria trifolia* and *Hydrocharis dubia*, were C1 and C5, respectively. A tristyle perennial, *Lythrum anceps* and a enantiostyle annual, *Monochoria korsakowii*, were C1 and B, respectively.

By examining flower-visitor communities, floral morphology, visitor behavior and pollen attachment on visitor's body, we inferred pollination guilds (Table 2). Flower guild expected from cluster analysis largely coincided with pollination guild. There were three kinds of exceptions: (1) four anemophilous plant species, i.e., *Isachne globosa, Leesia japonica, Phragmites communis* (Gramineae) and *Scirpus triqueter* (Cyperaceae), visited by hoverflies of the tribe Melanostomatini (Plate 1, L) and other flies, (2) one anemophilous plant species, i.e., *Typha angustifolia* (Typhaceae), visited by ovule-parasitic languriid beetles, and (3) long-tubed flower species, *Weigela hortensis* (Caprifoliaceae), *Cirsium sieboldii* (Asteraceae) and *Iris laevigata* (Iridaceae), which were mainly visited by butterflies or small bees (Plate 1, I) but are thought to be originally visited and pollinated by the long-tongued bumblebee, *Bombus diversus*. Enantiosyle flowers of *Monochoria korsakowii* were visited by small bees and syrphid flies (Plate 1, G), whereas they are reported to be visited by larger bees such as *Bombus, Xylocopa* and *Apis* in a natural localities (Wang *et al.*, 1995).

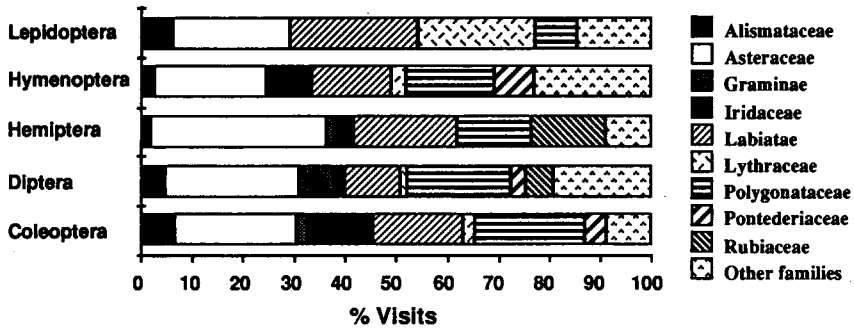


Fig. 13. Flower spectra (sorted by families) of five dominant insect orders.

## 6. Floral hosts of anthophilous insects

### 6.1. *General Pattern*

Floral host species varied greatly among insect families and species (Appendix 2). The plant families which were most frequently utilized by insects was Asteraceae (25.4 % of total visits), followed by Polygonaceae (18.5 %), Labiatae (13.7 %), Gramineae (4.2 %), Iridaceae (4.2 %), Rubiaceae (4.2 %), Alismataceae (4.1 %), Pontederiaceae (3.8 %), Lythraceae (2.8 %) and Brassicaceae (2.8 %). Figure 13 shows a comparison of flower visiting patterns among five dominant insect orders. The orders except Lepidoptera had similar patterns, whereas Hymenoptera did not visit Gramineae. The floral host spectrum of Lepidoptera was characterized by preference to Lythraceae and ignorance of Iridaceae and Pontederiaceae.

### 6.2. *Floral hosts of Diptera*

Floral host spectra greatly varied among dominant syrphid fly species (≥ 7 individuals collected). Cluster analysis of the floral host spectra (using Ward's method) grouped syrphid species into four clusters at semi-partial $r^2 = 0.18$ (Fig. 14). Two species of tribe Melanostomatini, *Platycheirus pennipes* and *Melanostoma mellinum*, were separated by others by exclusive relationships with anemophilous flowers of Cyperaceae and Gramineae, respectively. *Platycheirus pennipes* visited *Scirpus triqueter* in the morning on July 30, and collected pollen and licking droplet on stigma. *Melanostoma mellinum* visited *Leesia japonica* flowers in early morning just after sunrise on August 5, and collected pollen. Both male and female of these species visited them (Table 4). Two species of the tribe Syrphini and two species of the tribe Eristalini shared the same cluster, and visited various families of flowers. *Mesembrius flaviceps* had strong preference to *Iris*. Four species of the tribe Eristalini were grouped in the same cluster, and were characterized by preference to Asteraceae and Polygonaceae.

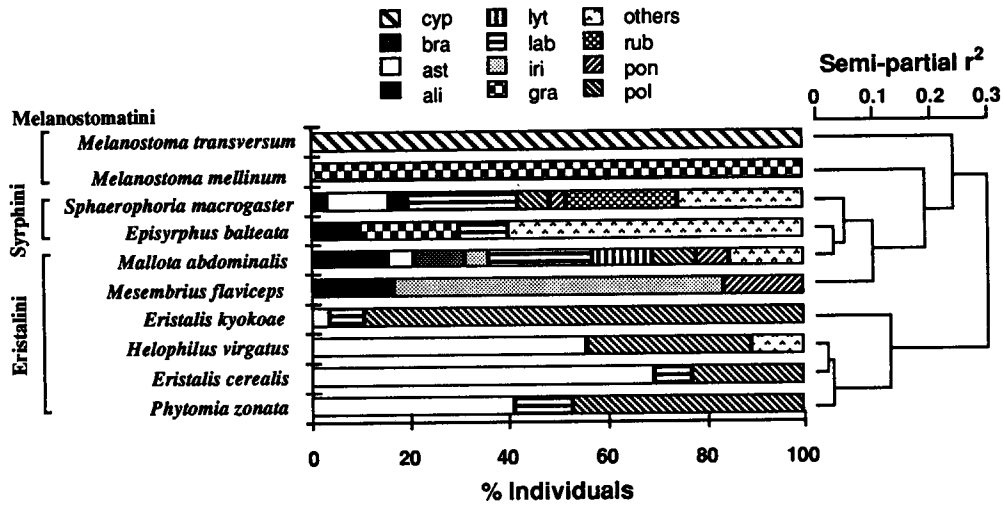


Fig. 14. Flower spectra (sorted by families) of ten dominant syrphid fly species (left) and dendrogram (right) derived from cluster analysis on the flower spectra.

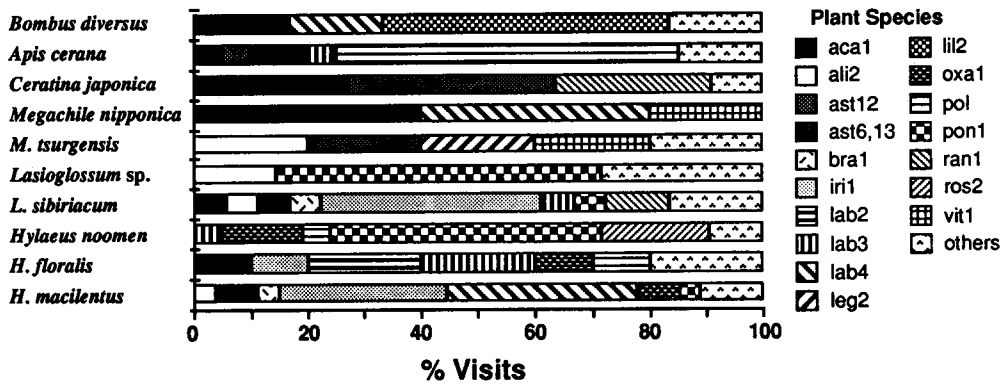


Fig. 15. Flower spectra (sorted by families) of ten dominant bee species.

6.3 *Floral hosts of Hymenoptera*

Floral host spectra of dominant bee species (≥ 7 individuals collected) varied greatly among bee species (Fig 15). Even in the same genus, *Hylaeus*, the spectra varied. *Hylaeus macilentus* frequently visited *Iris laevigata* in mid May (Plate 1, I), *Prunella vulgaris* in late June, both of which are thought to be pollinated by a long-tongued bumblebee, *Bombus diversus*. Only pollen but not nectar was harvested by *H. macilentus*. *Hylaeus noomen*, frequently visited *Rosa multiflora* in late June and *Monochoria korsakowii* flowers in late September and harvested pollen. No bee species were confirmed to be oligolectic. Floral host species of *Bombus diversus* in the marsh were *Solanum melongena* (Solanaceae), *Prunella vulgaris* (Labiatae), *Justicia procumbens* (Acanthaceae), *Adenophora triphylla* (Campanulaceae) and *Hosta albomarginata* (Liliaceae).

## Discussion

Among several studies on anthophilous insect communities conducted in Japan, this study is unique in that studied habitat is a wetland in warm temperate region. We discuss some characteristics of flower-insect relationships in the marsh by comparing them with those studied in a cool temperate coastal meadow at Hama-Koshimizu in east Hokkaido (Fukuda *et al.*, 1973), in subalpine coniferous forests and meadows at Mt. Kushigata in Yamanashi Pref. (Kato *et al.*, 1993), in temperate deciduous forests at Mt. Moiwa in Sapporo (Sakagami *et al.*, 1974), Rifu and Hanayama in Miyagi Pref. (Go'ukon, 1992), Ashu (Kato *et al.*, 1990), Kibune (Inoue *et al.*, 1990) in Kyoto Pref., at botanical gardens of Hokkaido University (Sakagami and Fukuda, 1973) and Kyoto University (Kakutani *et al.*, 1990), and in warm temperate forests at Wakayama (Matsuura *et al.*, 1972), Kochi (Ikudome, 1978) and Kagoshima (Ikudome, 1992).

Flowering phenology at Nakaikemi marshland was discriminated from those at woodlands by rarity of early bloomers. The only early bloomer was an asteraceous marsh perennial, *Senecio pierotii*. The rarity of early bloomers is thought to be due to scarcity of active insects in marshes in early spring. Since specific heat of water is greater than that of soil, the increase of temperature at waterlogged land is behind that at terrestrial, and emergence of insects is also behind time. The rarity of early bloomers may be also related with the rarity of andrenid bees most of which are active only in spring.

Anthophilous fauna at the marsh was characterized by dominance of Diptera over Hymenoptera; the percentage of collected individuals of Diptera was 58 % in this marsh, which is much higher than that of Ashu (35 %), Kibune (30 %), Kyoto (16 %) and Mt. Kushigata (33 %). The dominance of Diptera in the marsh results from the fact that permanently waterlogged land is favorable habitats for larvae of many dipterans but not for bees and wasps. Especially, dominant dipterans such as tribe Eristalini of Syrphidae and genera *Limnophora* and *Lispe* of Muscidae were aquatic or subaquatic saprophages.

The relative inferiority of bees in the marsh is thought to come from lack of dry nest site for underground nest makers. In fact, the proportion of underground nesting bees was lowest at the campus of Kyoto University in Kyoto (34.5%) and second lowest at Nakaikemi marsh (34.9 %) among various habitats (Hama-Koshimizu, 88.6 %; Sapporo, 80.3 %; Moiwa, 61.8 %; Rifu, 49.9 %; Hanayama, 66.4 %; Mt. Kushigata, 98.8 %; Ashu, 65.4 %; Kibune, 68.1 %; Wakayama, 76.2 %; Kochi, 75.6 %; Kagoshima, 88.6 %) (Fig. 16).

Bee community at Nakaikemi marsh was unique also in that Hylaeinae was the most abundant subfamily (Fig. 16). Hylaeine bees nest in pre-existing cavities especially dead shoot of reed. Although wetlands are relatively unimportant habitats for bees, a few specialist species utilize plant material for nesting sites (Falk, 1991). An extreme specialist bee in Europe, *H. pectoralis*, nests exclusively in old galles induced in the flower heads of the reed *Phragmites communis*, by larvae of the chloropid fly, *Lipara luscens* (O'Toole and Raw, 1991). The most abundant bee in Nakaikemi marsh, *Hylaeus macilentus*, may also be another example, whereas its nest has not yet been found. This minute bee species has been recorded only at three localities (probably wetlands) in Honshu and Hokkaido (Ikudome, 1989).

Hoverfly community at Nakaikemi marsh was next compared with those at woodlands at Ashu and Kibune, botanical garden of Kyoto University, and subalpine coniferous forests and

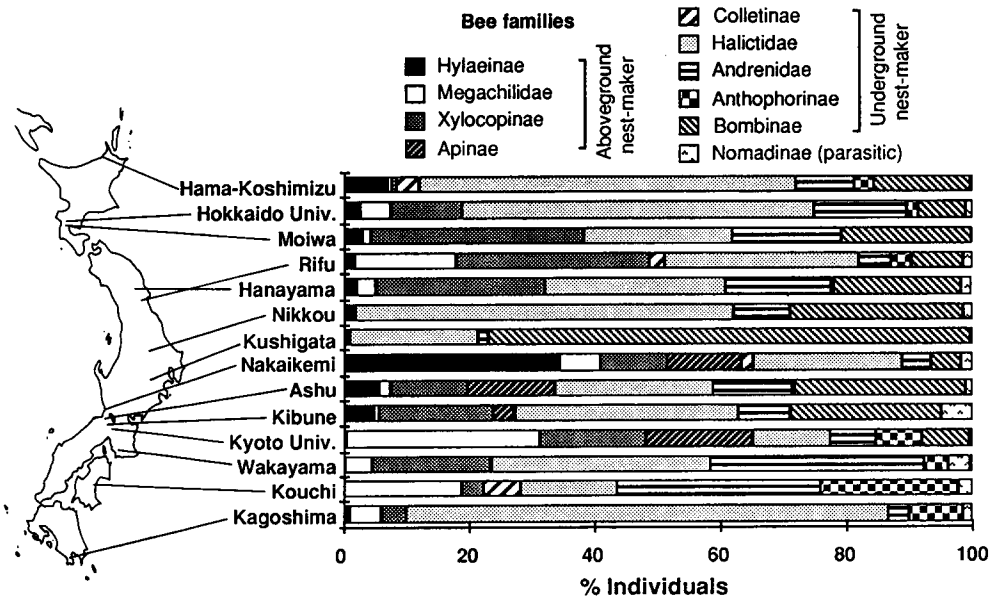


Fig. 16. A comparison of relative abundance of bee subfamilies among 14 localities in Japan. Data sources are as follows: Hama-Koshimizu (Fukuda *et al.*, 1973), Botanical garden of Hokkaido University in Sapporo (Sakagami and Fukuda, 1973), Mt. Moiwa (Sakagami *et al.*, 1974) in Hokkaido, Rifu and Hanayama in Miyagi Pref. (Go'ukon, 1992), Nikko in Gunma Pref. (Nakamura and Matsumura, 1985), Mt. Kushigata in Yamanashi Pref. (Kato *et al.*, 1993), Nakaikemi (this data), Ashu (Kato *et al.*, 1990), Kibune (Inoue *et al.*, 1990), Botanical garden of Kyoto University (Kakutani *et al.*, 1990) in Kyoto Pref., Wakayama (Matsuura *et al.*, 1972), Kochi (Ikudome, 1978) and Kagoshima (Ikudome, 1992).

meadows at Mt. Kushigata (Fig. 17), and characterized by relative abundance of saprophagous tribe Milesiini (Genus *Rhinotropidia*) (Fig. 17). Percentage of saprophages in collected hoverflies was highest at Nakaikemi (61 %), followed by Ashu (44.9 %), Kyoto (37.3 %), Mt. Kushigata (30.7 %) and Kibune (29.2 %). This suggests that syrphid fauna in the marsh is dominated by saprophagous groups most of which are aquatic or subaquatic. In turn, phytophagous groups (i.e., tribe Cheilosini) were rarer in the marsh and the botanical garden in Kyoto than at woodland habitats. Aphidophagous groups (i.e., tribe Syrphini) constituted more than 20 % at every habitat, and the percentage of them was highest in the urban habitat of the botanical garden in Kyoto.

A cluster analysis of flower-visitor spectra of 64 plant species distinguished seven flower guilds (Fig. 10). Among them, 24 species were fly flowers (A + C5), 26 spp. were bee flowers (B + C4), and 11 spp. were general flowers (C1). Irrespective of dominance of Diptera in the anthophilous community, 40.6 % of plant species were bee flowers, suggesting that the dominant *Hylaeus* bees are uniquely important pollinators. Thus, Nakaikemi marsh is regarded as a rare, important wetland habitat not only harboring many endangered plant and anthophilous insect species but also fostering characteristic insect-flower relationships.

Studied flowers included some weed species in traditional rice fields such as *Eusteralis*

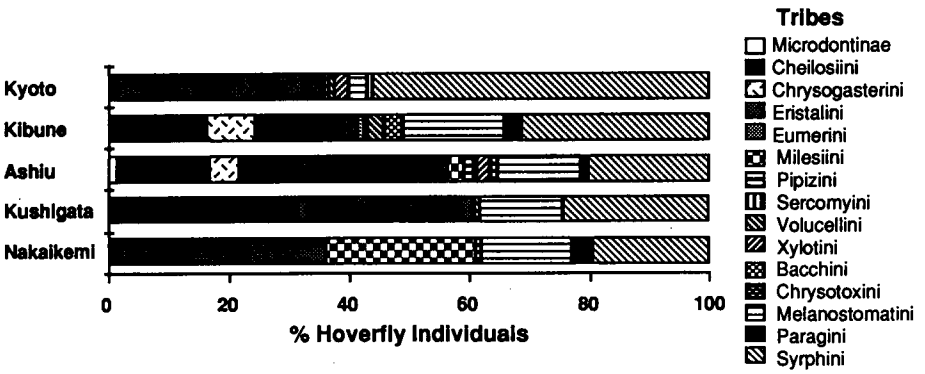


Fig. 17. A comparison of relative abundance of syrphid tribes among five localities in Japan. Data sources are as follows: Botanical garden of Kyoto University (Kakutani *et al.*, 1989), Kibune (Inoue *et al.*, 1989), Ashu (Kato *et al.*, 1989), Mt. Kushigata (Kato *et al.*, 1993) and Nakaikemi (this data).

*yatabeana, Limnophila sessiliflora, Lindernia procumbens, Alisma canaliculatum, Sagittaria trifolia, Monochoria korsakowii* and *M. vaginalis*. This study showed that these weed species were visited and probably pollinated by syrphid flies, calyptrate flies and small bees. *Monochoria vaginalis*, known to be an inbreeder, was also visited by a bee, *Hylaeus noomen*. A great genetic variation found in a moderately natural population of *Sagittaria trifolia* (Miura *et al.*, 1995) is consistent with these frequent visits by insects. Among these weed species, *Monochoria korsakowii* is now endangered. Recent rapid reduction of anthophilous insect populations caused by oberuse of insecticides in almost all rice fields must have been detrimental to this mainly outbreeding annual.

Finally, we discuss a ground plan to conserve the ecosystem of the marshland. Since a large part of the anthophilous fauna were inhabitants of various microhabitats of the marshlands, various types of habitats including reed swamps, *Zizania* marshes, channels and even traditionally cultivated rice fields should be conserved. Another standpoint for conservation is a continuum between wetlands and neighboring woodlands. Although there is no nest site of bumblebees in the marsh, there were four long-tubed flower species which are thought to have originally been pollinated by long-tongued bumblebees (Inoue and Kato, 1992). Probably due to reduction of population size and isolation from woodlands, some of these long-tubed flowers were not visited by bumblebees. An enantiostyle *Monochoria korsakowii* is also thought to have adapted to large or middle-sized bees' visits (Wang *et al.*, 1995), but they were visited only by small bees and syrphid flies in this marsh. The presence of these plant species pollinated by bumblebees suggests that the marshland should be conserved as a whole ecosystem by uniting the wetland and the surrounding woodlands.

**Acknowledgments**

We wish to thank Dr. O. Tadauch for identifying halictid and andrenid bees; Mr. T. Kimura for identifying syrphid flies. We are deeply indebted to Mrs. and Mr. Sasaki for their effort to conserve Nakaikemi marsh and for their guiding us geography, history and folklore of the marsh. This study is supported by a Japan Ministry of Education, Science and Culture Grant-in Aid for Scientific Research (#06640813).

**References**

Cronquist, A. 1981. *An integrated system of classification of flowering plants.* Columbia Univ. Press. New York.

Dugan, P. J. 1990. *Wetland conservation: A review of current issues and required action.* IUCN.

Falk, S. 1991. *A review of the scarce and threatened bees, wasps and ants of Great Britain.* Research and Survey in Nature Conservation No. 35. Nature Conservancy Council, Peterborough.

Ferrar, P. 1987. *A guide to the breeding habits and immature stages of Diptera Cyclorrhapha. Entomonograph* 8. E. J. Brill / Scandinavian Science Press, Leiden, Netherland.

Fisher, R. A., A. S. Corbet and C. B. Williams. 1943. The relation between the number of species and the number of individuals in a random sample of an animal population. *J. Anim. Ecol.* 12: 42-58.

Fukuda, H., S. F. Sakagami, K. Yamauchi and T. Tatsumura. 1973. Biofaunistic survey of wild bees in Hama-koshimizu, eastern Hokkaido. *Jap. J. Ecol.* 23: 160-170.

Go'ukon, K. 1992. Ecological survey on wild bee fauna in Hanayama-mura, Miyagi Prefecture. Reports of Scientific Studies on Hiyama-Tashiro Natural Environment Conservation Area. Miyagi Prefecture. pp. 197-212. (In Japanese)

Gilbert, F. and J. Owen. 1990. Size, shape, competition, and community structure in hoverflies (Diptera: Syrphidae). *J. Anim. Ecol.* 59: 21-39.

Ikudome, S. 1978. A wild bee survey in Kochi Plain (Kochi Pref.), Shikoku, Japan (Hymenoptera, Apoidea). *Kontyû, Tokyo,* 46: 512-536.

——— 1989. A revision of the family Colletidae of Japan (Hymenoptera: Apoidea). *Bull. Inst. Minami-Kyûshû Reg. Sci.* 5: 43-314.

——— 1992. The environment and the wild bee fauna of natural park in a city, with the result taken at Shiroyama Park in Kagoshima City, Japan, and with the appendix of a revised bee list recorded from the mainland of Kagoshima Prefecture (Hymenoptera, Apoidea). *Bull. Kagoshima Women's Junior College* 27: 99-135. (In Japanese)

Inoue, T. and M. Kato. 1992. Inter- and intraspecific morphological variation in bumblebee species and competition in flower utilization. In: M.D. Hunter, T. Ohgushi and P. W. Price (eds.), Effects of resource distribution on animal-plant interactions. pp. 394-432. Academic Press, Sandiego.

———, ———, T. Kakutani, T. Suka and T. Itino. 1990. Insect-flower relationship in the temperate deciduous forest of Kibune, Kyoto: An overview of the flowering phenology and the seasonal pattern of insect visits. *Contr. biol. Lab. Kyoto Univ.* 27: 377-463.

Kakutani, T., T. Inoue, M. Kato and H. Ichihashi. 1990. Insect-flower relationship at the campus of Kyoto University, Kyoto: An overview of the flowering phenology and the seasonal pattern of insect visits. *Contr. Biol. Lab. Kyoto Univ.* 27: 465-521.

Kadono, Y. 1994. *Aquatic Plants of Japan.* Bun-ichi Sogo Shuppan, Tokyo. (In Japanese)

Kato, M., T. Kakutani, T. Inoue and T. Itino. 1990. Insect-flower relationship in the primary beech forest of Ashu, Kyoto: An overview of the flowering phenology and the seasonal pattern of insect visits. *Contr. biol. Lab. Kyoto Univ.* 27: 309-375.

———, M. Matsumoto and T. Kato. 1993. Flowering phenology and anthophilous insect community in the cool-temperate subalpine forests and meadows at Mt. Kushigata in the central part of Japan. *Contr. biol. Lab. Kyoto Univ.* 28: 119-172.

Maekawa, F. 1943. Prehistoric-naturalized plants to Japan Proper. *Acta Phytotax. Geobot.* 13: 274-279.

Matsuura, M., S. F. Sakagami and H. Fukuda. 1974. A wild bee survey in Kibi (Wakayama Pref.), Southern Japan. *J. Fac. Sci. Hokkaido Univ. Ser. VI, Zool.* 19: 422-437.

May, R. M. 1975. Patterns of species abundance and diversity. In: M. L. Cody and J. M. Diamond (eds.), *Ecology and Evolution of communities* pp. 81-120. Belknap. Cambridge, Massachusetts.

Miura, R., C. An, T. Kusanagi and R. Terauchi. 1995. Detection of DNA fingerprints of *Sagittaria trifolia*. *Proc 15th Asian-Pacific Weed Sci. Soc. Conf.* 735-738.

Nakamura, K. and T. Matsumura. 1985. Biofaunistic survey of wild bees at highlands of Nikko, Kanto District, Japan. *Bull. Fac. General Education, Utsunomiya Univ.*, sec. 2, 18: 19-39. (In Japanese)

O'Toole C. and A. Raw. 1991. *Bees of the world.* Blandford, London.

Owen, J. and F. S. Gilbert. 1989. On the abundance of hoverflies (Syrphidae). *Oikos* 55: 183-193.

Preston, F. W. 1960. The canonical distribution of commonness and rarity. *Ecology* 43: 185-215, 410-432.

Red Data Book Committee Japan. 1989. *Red Data Book: Endengered plant species in Japan.* The Nature Conservation Society of Japan. Tokyo.

Richards, J. F. 1990. Agricultural Impacts in Tropical Wetlands: Rice paddies for mangroves in South and Southeast Asia. In: M. Williams (ed.), *Wetlands: A threatened landscape.* pp.217-233. Blackwell, Oxford.

Rotheray, G. E. 1993. *Colour guide to hoverfly larvae (Diptera, Syrphidae) in Britain and Europe.* Derek Whiteley, Sheffield.

Sakagami, S. F. and H. Fukuda. 1973. Wild bee survey at the campus of Hokkaido University. *J. Fac. Sci. Hokkaido Univ. Ser. VI, Zool.* 19: 190-250.

———, ———, H. Fukuda and H. Kawano. 1974. Problems and methods in wild bee surveys. *Seibutu-Kyouzai* 9: 1-60. (In Japanese)

Wang, G. R. Miura and T. Kusanagi. 1995. The enantiostyly and the pollination biology of *Monochoria korsakowii* (Pontederiaceae). *Acta Phytotax. Geobot.* 46: 55-65.

Washitani, I., H. Namai, R. Osawa and M. Niwa. 1991. Species biology of *Primula sieboldii* for the conservation of its lowland-habitat population: I. Inter-clonal variations in the flowering phenology, pollen load and female fertility components. *Pl. Species Biol.* 6: 27-37.

———, I., M. Kato, J. Nishihiro and K. Suzuki. 1995. Importance of queen bumble bees as pollinators faciliating inter-morph crossing in *Primula sieboldii. Pl. Species Biol.* 9: 169-176.

Watanabe, S. 1989. *Flora of Fukui Prefecture.* Shirasaki Press, Fukui. (in Japanese)

Williams, M. 1990. Agricultural Impacts in Temperate Wetlands. In: M. Williams (ed.), *Wetlands: A thretened landscape.* pp.181-216. Blackwell, Oxford.

Addresses of the authors:
(Mr) Makoto Kato, D. Agr. 加藤 真
Department of Natural Environment Sciences,
Faculty of Integrated Human Studies, Kyoto University 京都大学総合人間学部自然環境学科
Yoshida-Nihonmatsu-cho, Sakyo-ku, Kyoto. 606-01, JAPAN 京都市左京区吉田二本松町

(Mr) Reiichi Miura, M. Agr. 三浦励一
Weed Science Laboratory,
Faculty of Agriculture, Kyoto University 京都大学農学部雑草学教室
Kitashirakawa-Oiwake-cho, Sakyo-ku, Kyoto. 606-01, JAPAN 京都市左京区北白川追分町

APPENDIX 1

## A List of Insect Species Recorded on Flowers of 64 Plant Species at Nakaikemi Marsh in 1994-95

Insect-visit records for each plant species are listed as follows: insect species, (family code: order code), date, and (number of individuals collected). Plant taxa and insect taxa are arranged in the orders of Tables 2 and 3, respectively. Insect order code is abreviated as two head characters of each order name. Insect family codes are shown in Table 3.

### Saururaceae

*Houttuynia cordata*
*Episyrphus balteatus* (Syr: Di) 22-vi-94 (1)

### Nymphaeaceae

*Nymphaea marliacea*
*Lasioglossum percrassicepes* (Hal: Hy) 30-vi-95 (1)

### Ranunculaceae

*Ranunculus japonicus*
*Athemus lineatipennis* (Can: Co) 14-v-94 (1); *Cheilosia* sp.1 (Syr: Di) 14-v-94 (3); *Sphaerophoria macrogaster* (Syr: Di) 14-v-94 (1); *Lasioglossum sibiriacum* (Hal: Hy) 14-v-94 (2); *Lasioglossum jaonicum* (Hal: Hy) 14-v-94 (1); *Lasioglossum allodalum* (Hal: Hy) 14-v-94 (1); *Andrena knuthi* (And: Hy) 14-v-94 (2); *Andrena munutula* (And: Hy) 14-v-94 (1); *Ceratina japonica* (Ant: Hy) 14-v-94 (3)

### Papaveraceae

*Chelidonium majus* var. *asiaticum*
*Episyrphus balteatus* (Syr: Di) 5-viii-95 (1)

### Caryophyllaceae

*Stellaria media*
*Hylaeus macilentus* (Col: Hy) 22-vi-94 (1)

### Polygonaceae

*Persicaria comspicua*
*Limnophora* sp.2 (Mus: Di) 9-x-94 (1); sp. (Ich: Hy) 9-x-94 (1)

*Persicaria nipponensis*
*Sphaerophoria macrogaster* (Syr: Di) 28-ix-95 (1); *Helina* sp.1 (Mus: Di) 28-ix-95 (1); *Stomorhina obsoleta* (Cal: Di) 28-ix-95 (3); *Apis mellifera* (Api: Hy) 28-ix-95 (1)

*Persicaria sieboldi*
*Propylea japonica* (Coc: Co) 28-ix-95 (1); *Chaetocnema bicolorata* (Chr: Co) 28-ix-95 (6); *Coptosoma parvipictum* (Pla: He) 28-ix-95 (1); *Petaphora maritima* (Cer: He) 28-ix-95 (1); *Eristalis cerealis* (Syr: Di) 28-ix-95 (1); *Eristalis kyokoae* (Syr: Di) 2-x-94 (1), 28-ix-95 (3); *Rhinotropidia rostrata* (Syr: Di) 28-ix-95 (3); *Brontaea* sp. (Mus: Di) 28-ix-95 (1); *Graphomyia rufitibia* (Mus: Di) 28-ix-95 (2); *Helina* sp.3 (Mus: Di) 28-ix-95 (1); *Limnophora* sp.1 (Mus: Di) 28-ix-95 (2); *Limnophora* sp.4 (Mus: Di) 28-ix-95 (1); sp. (Mus: Di) 28-ix-95 (1); *Ravinia striata* (Sar: Di) 28-ix-95 (1); *Chrysomya pinguis* (Cal: Di) 28-ix-95 (2); *Lucilia caesar* (Cal: Di) 28-ix-95 (1); *Lucilia papuensis* (Cal: Di) 9-x-94 (1); *Stomorhina obsoleta* (Cal: Di) 28-ix-95 (12); *Agathis* sp. (Bra: Hy) 28-ix-95 (9); *Colletes palellatus* (Col: Hy) 28-ix-95 (1); *Apis cerana* (Api: Hy) 28-ix-95 (4)

*Persicaria thunbergii*
*Monolepta fulvicollis* (Chr: Co) 28-ix-95 (1); *Involvutus ilosus* (Att: Co) 9-x-94 (1); *Phytobius* sp.

(Cur: Co) 9-x-94 (1); *Eurydema rugosum* (Pen: He) 9-x-94 (1); *Tropidothorax cruciger* (Lyg: He) 2-x-94 (1); *Petaphora maritima* (Cer: He) 28-ix-95 (3); sp. (Del: He) 28-ix-95 (1); *Pipiza lugubrius* (Syr: Di) 9-x-94 (1); *Eristalinus viridis* (Syr: Di) 28-ix-95 (1); *Eristalis cerealis* (Syr: Di) 28-ix-95 (1), 9-x-94 (1); *Eristalis kyokoae* (Syr: Di) 2-x-94 (4), 28-ix-95 (5), 9-x-94 (12); *Helophilus virgatus* (Syr: Di) 2-x-94 (2), 9-x-94 (1); *Rhinotropidia rostrata* (Syr: Di) 28-ix-95 (2); *Melanostoma scalare* (Syr: Di) 28-ix-95 (1); *Phytomia zonata* (Syr: Di) 28-ix-95 (8); *Sphaerophoria macrogaster* (Syr: Di) 28-ix-95 (1); *Dolichopus nitidus* (Dol: Di) 28-ix-95 (4), 9-x-94 (2); *Homoneura* sp.1 (Lau: Di) 9-x-94 (1); *Dasyphora* sp. (Mus: Di) 9-x-94 (1); *Graphomyia rufitibia* (Mus: Di) 28-ix-95 (1); *Limnophora* sp.6 (Mus: Di) 28-ix-95 (1); *Aldrichina grahami* (Cal: Di) 9-x-94 (2); *Lucilia caesar* (Cal: Di) 28-ix-95 (1), 9-x-94 (1); *Lucilia papuensis* (Cal: Di) 28-ix-95 (1), 9-x-94 (1); *Stomorhina obsoleta* (Cal: Di) 2-x-94 (1), 28-ix-95 (3), 9-x-94 (3); *Echinomyia mikado* (Tac: Di) 9-x-94 (1); *Thelaira nigripes* (Tac: Di) 2-x-94 (1); *Parnara guttata guttata* (Hes: Le) 2-x-94 (2), 28-ix-95 (1); *Pelopidas mathias oberthueri* (Hes: Le) 28-ix-95 (1); sp. (Ich: Hy) 9-x-94 (1); sp. (Ich: Hy) 9-x-94 (1); *Agathis* sp. (Bra: Hy) 28-ix-95 (7); *Odontobracon* sp. (Bra: Hy) 9-x-94 (1); *Chelonus* sp. (Bra: Hy) 28-ix-95 (1); sp. (Eul: Hy) 28-ix-95 (1); sp. (Cha: Hy) 28-ix-95 (1); *Vespa simillima xanthoptera* (Ves: Hy) 9-x-94 (1); *Polistes chinensis antennalis* (Ves: Hy) 2-x-94 (1); *Hylaeus floralis* (Col: Hy) 28-ix-95 (1); *Hylaeus noomen* (Col: Hy) 28-ix-95 (1); *Apis cerana* (Api: Hy) 2-x-94 (1), 28-ix-95 (4), 9-x-94 (2)

*Persicaria yokusaiana*
*Stomorhina obsoleta* (Cal: Di) 9-x-94 (3)

**Guttiferae**

*Hypericum erectum*
*Rhinotropidia rostrata* (Syr: Di) 16-viii-94 (1)

**Brassicaceae**

*Cardamine lyrata*
*Eurydema rugosum* (Pen: He) 1-vi-95 (3); *Hydrometra procera* (Hyd: He) 1-vi-95 (1); *Tipula patagiata* (Tip: Di) 1-vi-95 (1); sp. (Sci: Di) 1-vi-95 (1); *Rhinotropidia rostrata* (Syr: Di) 1-vi-95 (6); *Melanostoma scalare* (Syr: Di) 1-vi-95 (2); *Limnia* sp. (Scm: Di) 1-vi-95 (1); *Dolichopus nitidus* (Dol: Di) 1-vi-95 (1); *Helina* sp.1 (Mus: Di) 1-vi-95 (7); *Arge nipponensis* (Arg: Hy) 1-vi-95 (1); *Hylaeus macilentus* (Col: Hy) 1-vi-95 (1); *Lasioglossum sibiriacum* (Hal: Hy) 1-vi-95 (1)

**Primulaceae**

*Lysimachia fortunei*
*Polytremis pellucida pellucida* (Hes: Le) 16-viii-94 (1); *Megachile nipponica* (Meg: Hy) 16-viii-94 (1)

**Rosaceae**

*Potentilla egedei* var. *grandis*
sp. (Tip: Di) 1-vi-95 (1); sp. (Sci: Di) 1-vi-95 (1); *Sphaerophoria macrogaster* (Syr: Di) 1-vi-95 (1); *Dolichopus nitidus* (Dol: Di) 1-vi-95 (1); sp. (Eph: Di) 1-vi-95 (1); sp. (Sph: Di) 1-vi-95 (2); sp. (Cac: Di) 1-vi-95 (2); *Helina* sp.1 (Mus: Di) 1-vi-95 (7); *Lasioglossum sibiriacum* (Hal: Hy) 1-vi-95 (1)

*Rosa multiflora*
*Hylaeus noomen* (Col: Hy) 30-vi-95 (4)

**Leguminosae**

*Aeschynomene indica*
*Ceratina japonica* (Ant: Hy) 28-ix-95 (1)

*Lespedeza bicolor*
*Eumenes samurai* (Eum: Hy) 28-ix-95 (1); *Megachile tsurugensis* (Meg: Hy) 28-ix-95 (1)

**Lythraceae**

*Lythrum anceps*

*Calomicrus* sp. (Chr: Co) 17-ix-94 (1); *Rhinotropidia rostrata* (Syr: Di) 17-ix-94 (7); *Parnara guttata guttata* (Hes: Le) 16-viii-94 (4), 17-ix-94 (5), 28-ix-95 (2); sp. (Bra: Hy) 17-ix-94 (1); sp. (Bra: Hy) 17-ix-94 (1); sp. (Enc: Hy) 17-ix-94 (3); *Hylaeus macilentus* (Col: Hy) 17-ix-94 (1); *Hylaeus noomen* (Col: Hy) 17-ix-94 (1)

**Onagraceae**

*Ludwigia epilobioides*

*Rhinotropidia rostrata* (Syr: Di) 16-viii-94 (3)

**Vitaceae**

*Ampelopsis brevipedunculata* var. *heterophylla*

*Eumenes micado* (Eum: Hy) 16-viii-94 (1); *Eumenes samurai* (Eum: Hy) 16-viii-94 (3); *Megachile tsurugensis* (Meg: Hy) 16-viii-94 (1); *Megachile nipponica* (Meg: Hy) 16-viii-94 (1)

**Oxalidaceae**

*Oxalis corniculata*

*Paragus jozanus* (Syr: Di) 28-ix-95 (1); *Paragus kaemorrhous* (Syr: Di) 28-ix-95 (1), 5-viii-95 (2); sp. (Eph: Di) 28-ix-95 (1); *Helina* sp.3 (Mus: Di) 28-ix-95 (1); *Hylaeus macilentus* (Col: Hy) 30-vi-95 (2); *Hylaeus floralis* (Col: Hy) 28-ix-95 (1); *Hylaeus noomen* (Col: Hy) 28-ix-95 (3)

**Umbelliferae**

*Oenanthe javanica*

*Rhinotropidia rostrata* (Syr: Di) 16-viii-94 (3); *Ravinia striata* (Sar: Di) 28-ix-95 (1); *Eutachina* sp. (Tac: Di) 16-viii-94 (1); *Parnara guttata guttata* (Hes: Le) 16-viii-94 (1); *Pelopidas mathias oberthueri* (Hes: Le) 28-vii-94 (1); *Polistes chinensis antennalis* (Ves: Hy) 16-viii-94 (1); *Anoplius eous* (Pom: Hy) 16-viii-94 (1); *Psen* sp. (Sph: Hy) 28-ix-95 (1); *Lasioglossum sibiriacum* (Hal: Hy) 16-viii-94 (1)

**Solanaceae**

*Solanum melongena*

*Lasioglossum sibiriacum* (Hal: Hy) 5-viii-95 (1); *Bombus diversus* (Api: Hy) 5-viii-95 (1)

**Verbenaceae**

*Clerodendrum trichotomum*

*Papilio helenus nicconicolens* (Pap: Le) 16-viii-94 (1)

**Labiatae**

*Eusteralis yatabeana*

*Conocephalus japonicus* (Tet: Or) 17-ix-94 (1); *Adomerus biguttulus* (Cyd: He) 28-ix-95 (1); *Petaphora maritima* (Cer: He) 17-ix-94 (3); *Eristalis cerealis* (Syr: Di) 28-ix-95 (1); *Eristalis kyokoae* (Syr: Di) 28-ix-95 (2); *Rhinotropidia rostrata* (Syr: Di) 16-viii-94 (2), 17-ix-94 (8); *Phytomia zonata* (Syr: Di) 28-ix-95 (2); *Limnia* sp. (Scm: Di) 17-ix-94 (1); *Dolichopus nitidus* (Dol: Di) 17-ix-94 (4); sp. (Eph: Di) 17-ix-94 (1); *Ravinia striata* (Sar: Di) 17-ix-94 (5), 28-ix-95 (1); *Lucilia papuensis* (Cal: Di) 28-ix-95 (1); *Stomorhina obsoleta* (Cal: Di) 17-ix-94 (3), 28-ix-95 (2); *Masicera* sp. (Tac: Di) 17-ix-94 (2); *Hymerria recurvalis* (Pyr: Le) 17-ix-94 (4), 28-ix-95 (2); *Parnara guttata guttata* (Hes: Le) 16-viii-94 (3), 17-ix-94 (1); sp. (Bra: Hy) 17-ix-94 (1); *Campsomeris grossa* (Sco: Hy) 28-ix-95 (1); *Oreumenes decoratus* (Eum: Hy) 28-ix-95 (1); *Hylaeus macilentus* (Col: Hy) 17-ix-94 (1)

*Lycopus ramosissimus* var. *japonicus*

*Sphaerophoria macrogaster* (Syr: Di) 28-ix-95 (1); *Ravinia striata* (Sar: Di) 28-ix-95 (1); *Servillia jokovlewii* (Tac: Di) 28-ix-95 (1); *Polistes chinensis antennalis* (Ves: Hy) 28-ix-95 (4); *Cyphononyx dorsalis* (Pom: Hy) 28-ix-95 (1); *Hylaeus floralis* (Col: Hy) 28-ix-95 (2); *Lasioglossum japonicum* (Hal: Hy) 28-ix-95 (1)

*Mosla dianthera*
*Conocephalus japonicus* (Tet: Or) 9-x-94 (1); *Calomicrus* sp. (Chr: Co) 9-x-94 (7); *Dolycoris bacculum* (Pen: He) 9-x-94 (1); *Nysius plebeius* (Lyg: He) 9-x-94 (3); *Episyrphus balteatus* (Syr: Di) 28-ix-95 (1); *Rhinotropidia rostrata* (Syr: Di) 9-x-94 (2); *Paragus kaemorrhous* (Syr: Di) 9-x-94 (1); *Sphaerophoria macrogaster* (Syr: Di) 28-ix-95 (6); *Eudorilas cruciator* (Pip: Di) 28-ix-95 (1), 9-x-94 (1); *Phaonia* sp.3 (Mus: Di) 9-x-94 (1); *Lucilia papuensis* (Cal: Di) 9-x-94 (1); sp. (Ten: Hy) 28-ix-95 (1); *Larra* sp. (Sph: Hy) 28-ix-95 (1); *Hylaeus floralis* (Col: Hy) 28-ix-95 (1), 9-x-94 (1); *Hylaeus noomen* (Col: Hy) 28-ix-95 (1); *Lasioglossum sibiriacum* (Hal: Hy) 9-x-94 (1); *Lasioglossum japonicum* (Hal: Hy) 28-ix-95 (1); *Lasioglossum exiliceps* (Hal: Hy) 9-x-94 (1); *Apis cerana* (Api: Hy) 2-x-94 (1)

*Prunella vulgaris* ssp. *asiatica*
*Cyphon* sp. (Hel: Co) 30-vi-95 (1); *Scotinophara lurida* (Pen: He) 30-vi-95 (1); *Petaphora maritima* (Cer: He) 30-vi-95 (2); sp. (Cer: Di) 30-vi-95 (1); sp. (Eph: Di) 30-vi-95 (1); sp. (Eph: Di) 30-vi-95 (1); *Hylaeus macilentus* (Col: Hy) 30-vi-95 (9); *Hylaeus floralis* (Col: Hy) 30-vi-95 (1); *Megachile nipponica* (Meg: Hy) 17-ix-94 (1), 30-vi-95 (1); *Ceratina esakii* (Ant: Hy) 30-vi-95 (1); *Ceratina flavipes* (Ant: Hy) 30-vi-95 (1); *Xylocopa appendiculata* (Ant: Hy) 22-vi-94 (1); *Bombus diversus* (Api: Hy) 22-vi-94 (1)

*Salvia japonica*
*Paragus jozanus* (Syr: Di) 9-x-94 (1); *Thelaira nigripes* (Tac: Di) 9-x-94 (1); *Hymerria recurvalis* (Pyr: Le) 9-x-94 (2); *Apis cerana* (Api: Hy) 9-x-94 (1)

## Plantaginaceae

*Plantago asiatica*
*Sphaerophoria macrogaster* (Syr: Di) 30-vi-95 (1)

## Scrophulariaceae

*Limophila sessiliflora*
*Rhinotropidia rostrata* (Syr: Di) 28-ix-95 (1); *Sphaerophoria macrogaster* (Syr: Di) 28-ix-95 (4); *Homoneura* sp.2 (Lau: Di) 28-ix-95 (1); sp. (Eph: Di) 28-ix-95 (1)

*Lindernia procumbens*
*Rhinotropidia rostrata* (Syr: Di) 28-ix-95 (1)

## Acanthaceae

*Justicia procumbens*
*Paragus quadrifasciatus* (Syr: Di) 17-ix-94 (1); *Lasioglossum sibiriacum* (Hal: Hy) 28-ix-95 (1); *Lasioglossum gorkiense* (Hal: Hy) 28-ix-95 (1); *Ceratina japonica* (Ant: Hy) 28-ix-95 (3); *Apis mellifera* (Api: Hy) 28-ix-95 (1); *Bombus diversus* (Api: Hy) 28-ix-95 (1); *Bombus hypocrita* (Api: Hy) 28-ix-95 (1)

## Campanulaceae

*Adenophora triphylla* var. *japonica*
*Episyrphus balteatus* (Syr: Di) 9-x-94 (2); *Helophilus virgatus* (Syr: Di) 9-x-94 (1); *Eurema hecabe* (Pie: Le) 16-viii-94 (1); *Lasioglossum mutilum* (Hal: Hy) 16-viii-94 (1); *Bombus diversus* (Api: Hy) 28-ix-95 (1)

## Rubiaceae

*Galium trifidum* var. *brevipedunculatum*
*Ischnura asiatica* (Agr: Od) 30-vi-95 (1); *Polymerus pekinensis* (Mir: He) 30-vi-95 (2); *Rhopalus maculatus* (Rho: He) 30-vi-95 (1); sp. (Del: He) 30-vi-95 (5); sp. (Chi: Di) 30-vi-95 (2); sp. (Chi: Di) 30-vi-95 (1); sp. (Chi: Di) 30-vi-95 (3); *Sphaerophoria macrogaster* (Syr: Di) 30-vi-95 (7); *Limnia* sp. (Scm: Di) 30-vi-95 (1); *Helina* sp.1 (Mus: Di) 30-vi-95 (15); *Gymnosoma* sp. (Tac: Di) 30-vi-95 (1)

## Caprifoliaceae

*Weigela hortensis*
*Papilio helenus nicconicolens* (Pap: Le) 14-v-94 (2); *Xylocopa appendiculata* (Ant: Hy) 14-v-94 (1)

## Asteraceae

*Bidens frondosa*
*Apis mellifera* (Api: Hy) 2-x-94 (1), 28-ix-95 (1)

*Cirsium japonicum*
sp. (Eph: Di) 17-v-94 (2); *Polytremis pellucida pellucida* (Hes: Le) 16-viii-94 (1); *Lasioglossum sibiriacum* (Hal: Hy) 22-vi-94 (1); *Lasioglolssum scitulum* (Hal: Hy) 22-vi-94 (1)

*Cirsium sieboldii*
*Homoneura extera* (Lau: Di) 28-ix-95 (6); *Xylocopa appendiculata* (Ant: Hy) 28-ix-95 (1)

*Eupatorium chinense*
*Oxycetonia jucunda* (Sca: Co) 16-viii-94 (2); *Ypthima argus* (Sat: Le) 16-viii-94 (1); sp. (Cha: Hy) 16-viii-94 (1); *Megachile nipponica* (Meg: Hy) 16-viii-94 (1)

*Eupatorium lindleyanum*
*Pteronemobius csikii* (Gry: Or) 28-ix-95 (1); *Oxycetonia jucunda* (Sca: Co) 17-ix-94 (1), 28-ix-95 (3); *Oulema erichsoni* (Chr: Co) 9-x-94 (1); *Tropidothorax cruciger* (Lyg: He) 28-ix-95 (1); *Nysius plebeius* (Lyg: He) 9-x-94 (3); *Piocoris varius* (Lyg: He) 28-ix-95 (1); *Lygocoris pallens* (Mir: He) 9-x-94 (4); sp. (Del: He) 17-ix-94 (1); *Eristalis cerealis* (Syr: Di) 17-ix-94 (1), 28-ix-95 (5); *Allograpta javana* (Syr: Di) 28-ix-95 (1); *Phytomia zonata* (Syr: Di) 28-ix-95 (3); sp. (Eph: Di) 28-ix-95 (1); *Drosophila* sp.2 (Dro: Di) 9-x-94 (1); *Limnophora* sp.1 (Mus: Di) 28-ix-95 (1); *Chrysomya pinguis* (Cal: Di) 28-ix-95 (1); *Phaenicia sericata* (Cal: Di) 9-x-94 (1); *Stomorhina obsoleta* (Cal: Di) 17-ix-94 (1), 28-ix-95 (33), 9-x-94 (1); sp. (Cal: Di) 28-ix-95 (1); *Masicera* sp. (Tac: Di) 9-x-94 (1); sp. (Tac: Di) 28-ix-95 (1); *Vespula lewisii* (Ves: Hy) 28-ix-95 (1); *Hylaeus noomen* (Col: Hy) 28-ix-95 (1); *Lasioglossum exiliceps* (Hal: Hy) 17-ix-94 (2)

*Ixeris debilis*
*Sphaerophoria macrogaster* (Syr: Di) 30-vi-95 (1); *Hylaeus macilentus* (Col: Hy) 30-vi-95 (2)

*Ixeris dentata*
*Tropidothorax cruciger* (Lyg: He) 14-v-94 (1); *Nomada nipponica* (Ant: Hy) 1-vi-95 (1); *Ceratina flavipes* (Ant: Hy) 14-v-94 (2)

*Kalimeris pinnatifida*
*Allograpta javana* (Syr: Di) 28-ix-95 (1); *Homoneura extera* (Lau: Di) 28-ix-95 (2); sp. (Eph: Di) 28-ix-95 (1); sp. (Ant: Di) 28-ix-95 (1); *Stomorhina obsoleta* (Cal: Di) 28-ix-95 (16); *Lycaena phlaeas daimio* (Lyc: Le) 28-ix-95 (1); *Agathis* sp. (Bra: Hy) 28-ix-95 (1); sp. (Bra: Hy) 28-ix-95 (3); sp. (Bra: Hy) 28-ix-95 (1); *Colletes palellatus* (Col: Hy) 28-ix-95 (2); *Megachile tsurugensis* (Meg: Hy) 28-ix-95 (1)

*Kalimeris yomena*
*Rhinotropidia rostrata* (Syr: Di) 16-viii-94 (1); *Agathis* sp. (Bra: Hy) 2-x-94 (1); *Stenodynerus* sp. (Eum: Hy) 5-viii-95 (1); *Eumenes samurai* (Eum: Hy) 2-x-94 (1); *Hylaeus floralis* (Col: Hy) 2-x-94 (1); *Apis cerana* (Api: Hy) 9-x-94 (1)

*Lactuca indica*
*Pipiza lugubrius* (Syr: Di) 9-x-94 (1); *Epistrophe* sp. (Syr: Di) 9-x-94 (1)

*Prenanthes tanakae*
*Tropidothorax belogolowi* (Lyg: He) 9-x-94 (1); *Helophilus virgatus* (Syr: Di) 9-x-94 (2); *Melanostoma scalare* (Syr: Di) 9-x-94 (1); *Phytomia zonata* (Syr: Di) 9-x-94 (4); *Homoneura extera* (Lau: Di) 9-x-94 (1); sp. (Eph: Di) 9-x-94 (1); *Stomorhina obsoleta* (Cal: Di) 9-x-94 (23); *Parnara*

*guttata guttata* (Hes: Le) 9-x-94 (3); *Pelopidas mathias oberthueri* (Hes: Le) 9-x-94 (1); *Argynnis paphia tsushimana* (Nym: Le) 9-x-94 (1); *Vespula vulgaris* (Ves: Hy) 9-x-94 (1); *Megachile tsurugensis* (Meg: Hy) 9-x-94 (1)

*Senecio pierotii*

*Athemus lineatipennis* (Can: Co) 14-v-94 (1); *Scymnus jamato* (Coc: Co) 14-v-94 (1); *Malachius prolongatus* (Mel: Co) 14-v-94 (1); *Nysius plebeius* (Lyg: He) 14-v-94 (5), 17-v-94 (1); *Phynocoris ornatus* (Red: He) 17-v-94 (1); sp. (Tip: Di) 17-v-94 (1); sp. (Sci: Di) 14-v-94 (1); *Cheilosia* sp.2 (Syr: Di) 17-v-94 (1); *Eristalis cerealis* (Syr: Di) 17-v-94 (3); *Eristalis kyokoae* (Syr: Di) 17-v-94 (1); *Helophilus virgatus* (Syr: Di) 17-v-94 (3); *Rhinotropidia rostrata* (Syr: Di) 14-v-94 (2); *Melanostoma scalare* (Syr: Di) 17-v-94 (1); *Rhamphomyia latistriata* (Emp: Di) 17-v-94 (3); *Phaonia* sp.3 (Mus: Di) 17-v-94 (1); sp. (Mus: Di) 17-v-94 (1); *Echinomyia mikado* (Tac: Di) 14-v-94 (1); *Thelaira* sp. (Tac: Di) 14-v-94 (1); *Thoressa varia* (Hes: Le) 14-v-94 (1); sp. (Ten: Hy) 17-v-94 (1); sp. (For: Hy) 14-v-94 (6); *Andrena knuthi* (And: Hy) 17-v-94 (2); *Osmia taurus* (Meg: Hy) 17-v-94 (1); *Ceratina japonica* (Ant: Hy) 14-v-94 (4)

*Taraxacum japonicum*

*Athemus lineatipennis* (Can: Co) 14-v-94 (1); *Sphaerophoria macrogaster* (Syr: Di) 14-v-94 (1), 28-ix-95 (1); *Argynnis paphia tsushimana* (Nym: Le) 28-ix-95 (2); sp. (Ich: Hy) 28-ix-95 (1); *Lasioglossum sibiriacum* (Hal: Hy) 17-v-94 (1); *Andrena knuthi* (And: Hy) 14-v-94 (2); *Andrena japonicum* (And: Hy) 17-v-94 (1); *Nomada fukuiana* (Ant: Hy) 14-v-94 (1); *Nomada nipponica* (Ant: Hy) 1-vi-95 (1), 17-v-94 (1); *Apis cerana* (Api: Hy) 14-v-94 (2)

## Alismataceae

*Alisma canaliculatum*

*Stratiomys* sp. (Syr: Di) 17-vii-94 (1); *Rhinotropidia rostrata* (Syr: Di) 28-vii-94 (1); *Mesembrius flaviceps* (Syr: Di) 17-vii-94 (1); *Sphaerophoria macrogaster* (Syr: Di) 17-vii-94 (1); *Helina* sp. (Mus: Di) 17-vii-94 (3); *Everes argiades hellotia* (Lyc: Le) 28-vii-94 (1)

*Sagittaria trifolia*

*Bagous* sp.2 (Cur: Co) 28-vii-94 (3); *Tropidothorax cruciger* (Lyg: He) 17-ix-94 (1); *Episyrphus balteatus* (Syr: Di) 28-ix-95 (1); *Rhinotropidia rostrata* (Syr: Di) 16-viii-94 (3), 17-ix-94 (5); *Mesembrius flaviceps* (Syr: Di) 17-ix-94 (1); *Sphaerophoria macrogaster* (Syr: Di) 5-viii-95 (1); sp. (Pho: Di) 28-vii-94 (1); *Dolichopus nitidus* (Dol: Di) 17-ix-94 (1), 28-ix-95 (1); sp. (Eph: Di) 28-ix-95 (3); *Ochtera mantis* (Eph: Di) 17-ix-94 (1); *Limnophora promineus* (Mus: Di) 28-ix-95 (5); *Limnophora* sp.6 (Mus: Di) 28-ix-95 (1); *Diasemia litterata* (Pyr: Le) 17-ix-94 (2); sp. (Bra: Hy) 17-ix-94 (1); *Hylaeus macilentus* (Col: Hy) 5-viii-95 (1); *Lasioglossum sibiriacum* (Hal: Hy) 16-viii-94 (1); *Lasioglossum percrassicepes* (Hal: Hy) 16-viii-94 (1), 28-vii-94 (1); *Lasioglossum affine* (Hal: Hy) 16-viii-94 (1); *Megachile tsurugensis* (Meg: Hy) 16-viii-94 (1)

## Hydrocharidaceae

*Hydrocharis dubia*

*Scymnus hoffmanni* (Coc: Co) 28-ix-95 (1); sp. (Cer: Di) 28-ix-95 (1); *Dolichopus nitidus* (Dol: Di) 28-ix-95 (4); *Dolichopus* sp. (Dol: Di) 28-ix-95 (3); *Homoneura extera* (Lau: Di) 28-ix-95 (2); sp. (Eph: Di) 28-ix-95 (1); *Drosophila* sp.1 (Dro: Di) 28-ix-95 (1); *Limnophora promineus* (Mus: Di) 28-ix-95 (4); *Limnophora* sp.3 (Mus: Di) 28-ix-95 (1); *Limnophora* sp.5 (Mus: Di) 28-ix-95 (1); *Limnophora* sp.6 (Mus: Di) 28-ix-95 (1); *Lispe* sp. (Mus: Di) 28-ix-95 (1)

## Commelinaceae

*Commelina communis*

*Episyrphus balteatus* (Syr: Di) 28-ix-95 (1)

*Murdannia keisak*

*Paragus kaemorrhous* (Syr: Di) 28-ix-95 (1); *Sphaerophoria macrogaster* (Syr: Di) 28-ix-95 (1)

**Gramineae**

*Isachne globosa*
*Melanostoma mellinum* (Syr: Di) 28-vii-94 (1), 5-viii-95 (7); *Limnia* sp. (Scm: Di) 5-viii-95 (1); sp.2 (Ant: Di) 5-viii-95 (1)

*Leesia japonica*
*Episyrphus balteatus* (Syr: Di) 5-viii-95 (2); *Melanostoma mellinum* (Syr: Di) 5-viii-95 (14); sp.2 (Ant: Di) 5-viii-95 (1); *Ravinia striata* (Sar: Di) 5-viii-95 (1)

*Phragmites communis*
*Dienerella* sp.2 (Lat: Co) 28-ix-95 (1); *Orthopagus lunulifer* (Dic: He) 28-ix-95 (1); sp. (Sci: Di) 28-ix-95 (1); sp. (Chi: Di) 28-ix-95 (2); sp. (Chi: Di) 28-ix-95 (1); sp. (Pho: Di) 28-ix-95 (1); *Drosophila* sp.1 (Dro: Di) 28-ix-95 (1); *Limnophora* sp.1 (Mus: Di) 28-ix-95 (1); *Phaonia* sp.1 (Mus: Di) 28-ix-95 (1); *Phaonia* sp.2 (Mus: Di) 28-ix-95 (1)

**Cyperaceae**

*Scirpus triqueter*
*Scotinophara lurida* (Pen: He) 30-vi-95 (1); *Platycheirus pennipes* (Syr: Di) 30-vi-95 (8); *Sphaerophoria macrogaster* (Syr: Di) 28-vii-94 (1)

**Typhaceae**

*Typha angustifolia*
*Cryptophilus* sp. (Lan: Co) 28-vii-94 (2)

**Pontederiaceae**

*Monochoria korsakowii*
*Dienerella* sp.1 (Lat: Co) 28-vii-94 (1); *Bagous* sp.1 (Cur: Co) 28-vii-94 (1); *Eristalinus viridis* (Syr: Di) 2-x-94 (1), 28-ix-95 (2); *Rhinotropidia rostrata* (Syr: Di) 2-x-94 (1), 28-ix-95 (3); *Mesembrius flaviceps* (Syr: Di) 28-ix-95 (1); *Sphaerophoria macrogaster* (Syr: Di) 28-ix-95 (1); *Dolichopus nitidus* (Dol: Di) 28-ix-95 (2); sp. (Dol: Di) 28-ix-95 (1); sp. (Eph: Di) 2-x-94 (1); *Limnophora* sp.2 (Mus: Di) 28-ix-95 (1); sp. (Ich: Hy) 28-ix-95 (1); *Hylaeus macilentus* (Col: Hy) 2-x-94 (1); *Hylaeus floralis* (Col: Hy) 28-ix-95 (1); *Hylaeus noomen* (Col: Hy) 2-x-94 (2), 28-ix-95 (8); *Lasioglossum sibiriacum* (Hal: Hy) 16-viii-94 (1); *Lasioglossum percrassicepes* (Hal: Hy) 28-ix-95 (1), 28-vii-94 (3)

*Monochoria vaginalis*
*Hylaeus noomen* (Col: Hy) 28-ix-95 (1)

**Iridaceae**

*Iris laevigata*
*Cyphon* sp. (Hel: Co) 1-vi-95 (3); *Calomicrus* sp. (Chr: Co) 1-vi-95 (1); *Donacia provostii* (Chr: Co) 1-vi-95 (2); *Tropidothorax cruciger* (Lyg: He) 1-vi-95 (1); sp. (Nab: He) 1-vi-95 (1); *Rhinotropidia rostrata* (Syr: Di) 1-vi-95 (3); *Mesembrius flaviceps* (Syr: Di) 1-vi-95 (4); *Microdon japonicus* (Syr: Di) 1-vi-95 (1); sp. (Eph: Di) 1-vi-95 (1); *Helina* sp.2 (Mus: Di) 1-vi-95 (1); *Lagidina platyeerus* (Ten: Hy) 1-vi-95 (2); sp. (Ich: Hy) 1-vi-95 (2); *Hylaeus macilentus* (Col: Hy) 1-vi-95 (8); *Hylaeus floralis* (Col: Hy) 1-vi-95 (1); *Lasioglossum sibiriacum* (Hal: Hy) 1-vi-95 (7); *Lasioglossum affine* (Hal: Hy) 1-vi-95 (1)

**Liliaceae**

*Alium grayi*
*Lasioglossum mutilum* (Hal: Hy) 22-vi-94 (1)

*Hosta albomarginata*
*Haplothrips* sp. (Phl: Th) 28-vii-94 (2); *Episyrphus balteatus* (Syr: Di) 5-viii-95 (1); *Bombus diversus* (Api: Hy) 16-viii-94 (1), 28-vii-94 (1), 5-viii-95 (1)

APPENDIX 2

## A List of Floral Host Species for Each Anthophilous Insect Species Recorded at Nakaikemi Marsh in 1994-95

Flower-visit records of each insect species are arranged in the following order: plant species, (plant species code), date and (number of individuals). Insect taxa and plant taxa are arranged in the order in Table 3 and 2, respectively.

### ODONATA

#### Agrionidae

*Ischnura asiatica*
*Galium trifidum* var. *brevipedunculatum* (rub1) 30-vi-95 (1)

### ORTHOPTERA

#### Tettigoniidae

*Conocephalus japonicus*
*Eusteralis yatabeana* (lab1) 17-ix-94 (1); *Mosla dianthera* (lab3) 9-x-94 (1)

#### Gryllidae

*Pteronemobius csikii*
*Eupatorium lindleyanum* (ast5) 28-ix-95 (1)

### THYSANOPTERA

#### Phlaeothripidae

*Haplothrips* sp.
*Hosta albo-marginata* (lil2) 28-vii-94 (2)

### HEMIPTERA

#### Pentatomidae

*Dolycoris bacculum*
*Mosla dianthera* (lab3) 9-x-94 (1)

*Eurydema rugosum*
*Persicaria thunbergii* (pol4) 9-x-94 (1); *Cardamine lyrata* (bra1) 1-vi-95 (3)

*Scotinophara lurida*
*Prunella vulgaris* ssp. *asiatica* (lab4) 30-vi-95 (1); *Scirpus triqueter* (cyp1) 30-vi-95 (1)

#### Cydnidae

*Adomerus biguttulus*
*Eusteralis yatabeana* (lab1) 28-ix-95 (1)

#### Platispidae

*Coptosoma parvipictum*
*Persicaria sieboldi* (pol3) 28-ix-95 (1)

#### Lygaeidae

*Tropidothorax belogolowi*
*Prenanthes tanakae* (ast11) 9-x-94 (1)

*Tropidothorax cruciger*
*Persicaria thunbergii* (pol4) 2-x-94 (1); *Eupatorium lindleyanum* (ast5) 28-ix-95 (1); *Ixeris dentata* (ast7) 14-v-94 (1); *Sagittaria trifolia* (ali2) 17-ix-94 (1); *Iris laevigata* (iri1) 1-vi-95 (1)

*Nysius plebeius*
*Mosla dianthera* (lab3) 9-x-94 (3); *Eupatorium lindleyanum* (ast5) 9-x-94 (3); *Senecio pierotii* (ast12) 14-v-94 (5), 17-iv-94 (1)

*Piocoris varius*
*Eupatorium lindleyanum* (ast5) 28-ix-95 (1)

**Miridae**

*Lygocoris pallens*
*Eupatorium lindleyanum* (ast5) 9-x-94 (4)

*Polymerus pekinensis*
*Galium trifidum* var. *brevipedunculatum* (rub1) 30-vi-95 (2)

**Rhopalidae**

*Rhopalus maculatus*
*Galium trifidum* var. *brevipedunculatum* (rub1) 30-vi-95 (1)

**Reduviidae**

*Phynocoris ornatus*
*Senecio pierotii* (ast12) 17-iv-94 (1)

**Nabidae**

sp. 1
*Iris laevigata* (iri1) 1-vi-95 (1)

**Hydrometridae**

*Hydrometra procera*
*Cardamine lyrata* (bra1) 1-vi-95 (1)

**Cercopidae**

*Petaphora maritima*
*Persicaria sieboldi* (pol3) 28-ix-95 (1); *Persicaria thunbergii* (pol4) 28-ix-95 (3); *Eusteralis yatabeana* (lab1) 17-ix-94 (3); *Prunella vulgaris* ssp. *asiatica* (lab4) 30-vi-95 (2)

**Deltocephalidae**

sp. 1
*Persicaria thunbergii* (pol4) 28-ix-95 (1)

sp. 2
*Galium trifidum* var. *brevipedunculatum* (rub1) 30-vi-95 (5)

sp. 3
*Eupatorium lindleyanum* (ast5) 17-ix-94 (1)

**Dictyopharidae**

*Orthopagus lunulifer*
*Phragmites communis* (gra3) 28-ix-95 (1)

## COLEOPTERA

### Scarabaeidae

*Oxycetonia jucunda*
*Eupatorium chinense* (ast4) 16-viii-94 (2); *Eupatorium lindleyanum* (ast5) 17-ix-94 (1), 28-ix-95 (3)

### Helodidae

*Cyphon* sp.
*Prunella vulgaris* ssp. *asiatica* (lab4) 30-vi-95 (1); *Iris laevigata* (iri1) 1-vi-95 (3)

### Cantharidae

*Athemus lineatipennis*
*Ranunculus japonicus* (ran1) 14-v-94 (1); *Senecio pierotii* (ast12) 14-v-94 (1); *Taraxacum japonicum* (ast13) 14-v-94 (1)

### Coccinellidae

*Propylea japonica*
*Persicaria sieboldi* (pol3) 28-ix-95 (1)

*Scymnus jamato*
*Senecio pierotii* (ast12) 14-v-94 (1)

*Scymnus hoffmanni*
*Hydrocharis dubia* (hyd1) 28-ix-95 (1)

### Melyridae

*Malachius prolongatus*
*Senecio pierotii* (ast12) 14-v-94 (1)

### Lathridiidae

*Dienerella* sp. 1
*Monochoria korsakowii* (pon1) 28-vii-94 (1)

*Dienerella* sp. 2
*Phragmites communis* (gra3) 28-ix-95 (1)

### Languriidae

*Cryptophilus* sp.
*Typha angustifolia* (typ1) 28-vii-94 (2)

### Chrysomelidae

*Calomicrus* sp.
*Lythrum anceps* (lyt1) 17-ix-94 (1); *Mosla dianthera* (lab3) 9-x-94 (7); *Iris laevigata* (iri1) 1-vi-95 (1)

*Monolepta fulvicollis*
*Persicaria thunbergii* (pol4) 28-ix-95 (1)

*Oulema erichsoni*
*Eupatorium lindleyanum* (ast5) 9-x-94 (1)

*Chaetocnema bicolorata*
*Persicaria sieboldi* (pol3) 28-ix-95 (6)

*Donacia provostii*
*Iris laevigata* (iri1) 1-vi-95 (2)

**Attelabidae**

*Involvutus ilosus*
*Persicaria thunbergii* (pol4) 9-x-94 (1)

**Curculionidae**

*Phytobius* sp.
*Persicaria thunbergii* (pol4) 9-x-94 (1)

*Bagous* sp. 1
*Monochoria korsakowii* (pon1) 28-vii-94 (1)

*Bagous* sp. 2
*Sagittaria trifolia* (ali2) 28-vii-94 (3)

**DIPTERA**

**Tipulidae**

*Tipula patagiata*
*Cardamine lyrata* (bra1) 1-vi-95 (1)

sp. 1
*Potentilla egedei* var. *grandis* (ros1) 1-vi-95 (1)

sp. 2
*Senecio pierotii* (ast12) 17-iv-94 (1)

**Sciaridae**

sp. 1
*Cardamine lyrata* (bra1) 1-vi-95 (1); *Potentilla egedei* var. *grandis* (ros1) 1-vi-95 (1); *Senecio pierotii* (ast12) 14-v-94 (1)

sp. 2
*Phragmites communis* (gra3) 28-ix-95 (1)

**Chironomidae**

sp. 1
*Phragmites communis* (gra3) 28-ix-95 (2)

sp. 2
*Galium trifidum* var. *brevipedunculatum* (rub1) 30-vi-95 (2); *Phragmites communis* (gra3) 28-ix-95 (1)

sp. 3
*Galium trifidum* var. *brevipedunculatum* (rub1) 30-vi-95 (1)

sp. 4
*Galium trifidum* var. *brevipedunculatum* (rub1) 30-vi-95 (3)

**Ceratopogonidae**

sp. 1
*Prunella vulgaris* ssp. *asiatica* (lab4) 30-vi-95 (1); *Hydrocharis dubia* (hyd1) 28-ix-95 (1)

**Empididae**

*Rhamphomyia latistriata*
*Senecio pierotii* (ast12) 17-iv-94 (3)

**Stratiomyidae**

*Stratiomys* sp.
*Alisma canaliculatum* (ali1) 17-vii-94 (1)

**Syrphidae**

*Allograpta javana*
*Kalimeris pinnatifida* (ast8) 28-ix-95 (1); *Eupatorium lindleyanum* (ast5) 28-ix-95 (1)

*Cheilosia* sp. 1
*Ranunculus japonicus* (ran1) 14-v-94 (3)

*Cheilosia* sp. 2
*Senecio pierotii* (ast12) 17-iv-94 (1)

*Episyrphus balteatus*
*Houttuynia cordata* (sau1) 22-vi-94 (1); *Chelidonium majus* var. *asiaticum* (pap1) 5-viii-95 (1); *Mosla dianthera* (lab3) 28-ix-95 (1); *Adenophora triphylla* var. *japonica* (cam1) 9-x-94 (2); *Sagittaria trifolia* (ali2) 28-ix-95 (1); *Commelina communis* (com1) 28-ix-95 (1); *Leesia japonica* (gra2) 5-viii-95 (2); *Hosta albo-marginata* (lil2) 5-viii-95 (1)

*Eristalinus viridis*
*Persicaria thunbergii* (pol4) 28-ix-95 (1); *Monochoria korsakowii* (pon1) 2-x-94 (1), 28-ix-95 (2)

*Eristalis cerealis*
*Persicaria sieboldi* (pol3) 28-ix-95 (1); *Persicaria thunbergii* (pol4) 28-ix-95 (1), 9-x-94 (1); *Eusteralis yatabeana* (lab1) 28-ix-95 (1); *Eupatorium lindleyanum* (ast5) 17-ix-94 (1), 28-ix-95 (5); *Senecio pierotii* (ast12) 17-iv-94 (3)

*Eristalis kyokoae*
*Persicaria sieboldi* (pol3) 2-x-94 (1), 28-ix-95 (3); *Persicaria thunbergii* (pol4) 2-x-94 (4), 28-ix-95 (5), 9-x-94 (12); *Eusteralis yatabeana* (lab1) 28-ix-95 (2); *Senecio pierotii* (ast12) 17-iv-94 (1)

*Eristrophe* sp.
*Lactuca indica* (ast10) 9-x-94 (1)

*Helophilus virgatus*
*Persicaria thunbergii* (pol4) 2-x-94 (2), 9-x-94 (1); *Adenophora triphylla* var. *japonica* (cam1) 9-x-94 (1); *Prenanthes tanakae* (ast11) 9-x-94 (2); *Senecio pierotii* (ast12) 17-iv-94 (3)

*Melanostoma mellinum*
*Isachne globosa* (gra1) 28-vii-94 (1), 5-viii-95 (7); *Leesia japonica* (gra2) 5-viii-95 (14)

*Melanostoma scalare*
*Persicaria thunbergii* (pol4) 28-ix-95 (1); *Cardamine lyrata* (bra1) 1-vi-95 (2); *Prenanthes tanakae* (ast11) 9-x-94 (1); *Senecio pierotii* (ast12) 17-iv-94 (1)

*Mesembrius flaviceps*
*Alisma canaliculatum* (ali1) 17-vii-94 (1); *Sagittaria trifolia* (ali2) 17-ix-94 (1); *Monochoria korsakowii* (pon1) 28-ix-95 (1); *Iris laevigata* (iri1) 1-vi-95 (4)

*Microdon japonicus*
*Iris laevigata* (iri1) 1-vi-95 (1)

*Paragus quadrifasciatus*
*Justicia procumbens* (aca1) 17-ix-94 (1)

*Paragus jozanus*
*Oxalis corniculata* (oxa1) 28-ix-95 (1); *Salvia japonica* (lab5) 9-x-94 (1)

*Paragus kaemorrhous*
*Oxalis corniculata* (oxa1) 28-ix-95 (1), 5-viii-95 (2); *Mosla dianthera* (lab3) 9-x-94 (1); *Murdannia keisak* (com2) 28-ix-95 (1)

*Phytomia zonata*
*Persicaria thunbergii* (pol4) 28-ix-95 (8); *Eusteralis yatabeana* (lab1) 28-ix-95 (2); *Eupatorium lindleyanum* (ast5) 28-ix-95 (3); *Prenanthes tanakae* (ast11) 9-x-94 (4)

*Pipiza lugubrius*
*Persicaria thunbergii* (pol4) 9-x-94 (1); *Lactuca indica* (ast10) 9-x-94 (1)

*Platycheirus pennipes*
*Scirpus triqueter* (cyp1) 30-vi-95 (8)

*Rhinotropidia rostrata*
*Persicaria sieboldi* (pol3) 28-ix-95 (3); *Persicaria thunbergii* (pol4) 28-ix-95 (2); *Hypericum erectum* (gut1) 16-viii-94 (1); *Cardamine lyrata* (bra1) 1-vi-95 (6); *Lythrum anceps* (lyt1) 17-ix-94 (7); *Ludwigia epilobioides* (ona1) 16-viii-94 (3); *Oenanthe javanica* (umb1) 16-viii-94 (3); *Eusteralis yatabeana* (lab1) 16-viii-94 (2), 17-ix-94 (8); *Mosla dianthera* (lab3) 9-x-94 (2); *Limophila sessiliflora* (scr1) 28-ix-95 (1); *Lindernia procumbens* (scr2) 16-viii-94 (1); *Kalimeris yomena* (ast9) 16-viii-94 (1); *Senecio pierotii* (ast12) 14-v-94 (2); *Alisma canaliculatum* (ali1) 17-vii-94 (1); 28-vii-94 (1); *Sagittaria trifolia* (ali2) 16-viii-94 (3), 17-ix-94 (5); *Monochoria korsakowii* (pon1) 2-x-94 (1), 28-ix-95 (3); *Iris laevigata* (iri1) 1-vi-95 (3)

*Sphaerophoria macrogaster*
*Ranunculus japonicus* (ran1) 14-v-94 (1); *Persicaria nipponensis* (pol2) 28-ix-95 (1); *Persicaria thunbergii* (pol4) 28-ix-95 (1); *Potentilla egedei* var. *grandis* (ros1) 1-vi-95 (1); *Lycopus ramosissimus* var. *japonicus* (lab2) 28-ix-95 (1); *Mosla dianthera* (lab3) 28-ix-95 (6); *Plantago asiatica* (pla1) 30-vi-95 (1); *Limophila sessiliflora* (scr1) 28-ix-95 (4); *Galium trifidum* var. *brevipedunculatum* (rub1) 30-vi-95 (7); *Ixeris debilis* (ast6) 30-vi-95 (1); *Taraxacum japonicum* (ast13) 14-v-94 (1), 28-ix-95 (1); *Sagittaria trifolia* (ali2) 5-viii-95 (1); *Murdannia keisak* (com2) 28-ix-95 (1); *Alisma canaliculatum* (ali1) 17-vii-94 (1); *Scirpus triqueter* (cyp1) 28-vii-94 (1); *Monochoria korsakowii* (pon1) 28-ix-95 (1)

## Pipunculidae

*Eudorilas cruciator*
*Mosla dianthera* (lab3) 28-ix-95 (1), 9-x-94 (1)

## Phoridae

sp. 1
*Sagittaria trifolia* (ali2) 28-vii-94 (1)

sp. 2
*Phragmites communis* (gra3) 28-ix-95 (1)

## Sciomyzidae

*Limnia* sp.
*Cardamine lyrata* (bra1) 1-vi-95 (1); *Eusteralis yatabeana* (lab1) 17-ix-94 (1); *Galium trifidum* var. *brevipedunculatum* (rub1) 30-vi-95 (1); *Isachne globosa* (gra1) 5-viii-95 (1)

*Sepedon aenescens*
*Persicaria comspicua* (pol1) 28-ix-95 (1)

**Dolichopodidae**

*Dolichopus nitidus*
*Persicaria thunbergii* (pol4) 28-ix-95 (4), 9-x-94 (2); *Cardamine lyrata* (bra1) 1-vi-95 (1); *Potentilla egedei* var. *grandis* (ros1) 1-vi-95 (1); *Eusteralis yatabeana* (lab1) 17-ix-94 (4); *Sagittaria trifolia* (ali2) 17-ix-94 (1), 28-ix-95 (1); *Hydrocharis dubia* (hyd1) 28-ix-95 (4); *Monochoria korsakowii* (pon1) 28-ix-95 (2)

*Dolichopus* sp.
*Hydrocharis dubia* (hyd1) 28-ix-95 (3)

sp. 1
*Monochoria korsakowii* (pon1) 28-ix-95 (1)

**Lauxaniidae**

*Homoneura extera*
*Cirsium sieboldii* (ast3) 28-ix-95 (6); *Kalimeris pinnatifida* (ast8) 28-ix-95 (2); *Prenanthes tanakae* (ast11) 9-x-94 (1); *Hydrocharis dubia* (hyd1) 28-ix-95 (2)

*Homoneura* sp.1
*Persicaria thunbergii* (pol4) 9-x-94 (1)

*Homoneura* sp.2
*Limophila sessiliflora* (scr1) 28-ix-95 (1)

**Ephydridae**

sp. 1
*Oxalis corniculata* (oxa1) 28-ix-95 (1); *Eusteralis yatabeana* (lab1) 17-ix-94 (1); *Prunella vulgaris* ssp. *asiatica* (lab4) 30-vi-95 (1); *Limophila sessiliflora* (scr1) 28-ix-95 (1); *Eupatorium lindleyanum* (ast5) 28-ix-95 (1); *Sagittaria trifolia* (ali2) 28-ix-95 (3); *Hydrocharis dubia* (hyd1) 28-ix-95 (1)

sp. 2
*Monochoria korsakowii* (pon1) 2-x-94 (1)

sp. 3
*Prenanthes tanakae* (ast11) 9-x-94 (1)

sp. 4
*Kalimeris pinnatifida* (ast8) 28-ix-95 (1)

sp. 5
*Prunella vulgaris* ssp. *asiatica* (lab4) 30-vi-95 (1); *Iris laevigata* (iri1) 1-vi-95 (1)

sp. 6
*Potentilla egedei* var. *grandis* (ros1) 1-vi-95 (1)

sp. 7
*Cirsium japonicum* (ast2) 17-iv-94 (2)

*Ochtera mantis*
*Sagittaria trifolia* (ali2) 17-ix-94 (1)

**Sphaeroceridae**

sp. 1
*Potentilla egedei* var. *grandis* (ros1) 1-vi-95 (2)

**Canaceidae**

sp. 1
*Potentilla egedei* var. *grandis* (ros1) 1-vi-95 (2)

**Drosophilidae**

*Drosophila* sp. 1
*Hydrocharis dubia* (hyd1) 28-ix-95 (1); *Phragmites communis* (gra3) 28-ix-95 (1)

*Drosophila* sp. 2
*Eupatorium lindleyanum* (ast5) 9-x-94 (1)

**Anthomyiidae**

sp. 1
*Kalimeris pinnatifida* (ast8) 28-ix-95 (1)

sp. 2
*Isachne globosa* (gra1) 5-viii-95 (1); *Leesia japonica* (gra2) 5-viii-95 (1)

**Muscidae**

*Brontaea* sp.
*Persicaria sieboldi* (pol3) 28-ix-95 (1)

*Dasyphora* sp.
*Persicaria thunbergii* (pol4) 9-x-94 (1)

*Graphomyia rufitibia*
*Persicaria sieboldi* (pol3) 28-ix-95 (2); *Persicaria thunbergii* (pol4) 28-ix-95 (1)

*Helina* sp. 1
*Persicaria nipponensis* (pol2) 28-ix-95 (1); *Cardamine lyrata* (bra1) 1-vi-95 (7); *Potentilla egedei* var. *grandis* (ros1) 1-vi-95 (7); *Galium trifidum* var. *brevipedunculatum* (rub1) 30-vi-95 (15); *Alisma canaliculatum* (ali1) 17-vii-94 (3)

*Helina* sp. 2
*Iris laevigata* (iri1) 1-vi-95 (1)

*Helina* sp. 3
*Persicaria sieboldi* (pol3) 28-ix-95 (1); *Oxalis corniculata* (oxa1) 28-ix-95 (1)

*Limnophora promineus*
*Sagittaria trifolia* (ali2) 28-ix-95 (5); *Hydrocharis dubia* (hyd1) 28-ix-95 (4)

*Limnophora* sp. 1
*Persicaria sieboldi* (pol3) 28-ix-95 (2); *Eupatorium lindleyanum* (ast5) 28-ix-95 (1); *Phragmites communis* (gra3) 28-ix-95 (1)

*Limnophora* sp. 2
*Persicaria comspicua* (pol1) 9-x-94 (1); *Monochoria korsakowii* (pon1) 28-ix-95 (1)

*Limnophora* sp. 3
*Hydrocharis dubia* (hyd1) 28-ix-95 (1)

*Limnophora* sp. 4
*Persicaria sieboldi* (pol3) 28-ix-95 (1)

*Limnophora* sp. 5
*Hydrocharis dubia* (hyd1) 28-ix-95 (1)

*Limnophora* sp.6
*Persicaria thunbergii* (pol4) 28-ix-95 (1); *Sagittaria trifolia* (ali2) 28-ix-95 (1); *Hydrocharis dubia* (hyd1) 28-ix-95 (1)

*Lispe* sp.
*Hydrocharis dubia* (hyd1) 28-ix-95 (1)

*Phaonia* sp. 1
*Phragmites communis* (gra3) 28-ix-95 (1)

*Phaonia* sp. 2
*Phragmites communis* (gra3) 28-ix-95 (1)

*Phaonia* sp. 3
*Mosla dianthera* (lab3) 9-x-94 (1); *Senecio pierotii* (ast12) 17-iv-94 (1)

sp. 1
*Senecio pierotii* (ast12) 17-iv-94 (1)

sp. 2
*Persicaria sieboldi* (pol3) 28-ix-95 (1)

## Sarcophagidae

*Ravinia striata*
*Persicaria sieboldi* (pol3) 28-ix-95 (1); *Oenanthe javanica* (umb1) 28-ix-95 (1); *Eusteralis yatabeana* (lab1) 17-ix-94 (5), 28-ix-95 (1); *Lycopus ramosissimus* var. *japonicus* (lab2) 28-ix-95 (1); *Leesia japonica* (gra2) 5-viii-95 (1)

## Calliphoridae

*Aldrichina grahami*
*Persicaria thunbergii* (pol4) 9-x-94 (2)

*Chrysomya pinguis*
*Persicaria sieboldi* (pol3) 28-ix-95 (2); *Eupatorium lindleyanum* (ast5) 28-ix-95 (1)

*Lucilia caesar*
*Persicaria sieboldi* (pol3) 28-ix-95 (1); *Persicaria thunbergii* (pol4) 28-ix-95 (1), 9-x-94 (1)

*Lucilia papuensis*
*Persicaria sieboldi* (pol3) 9-x-94 (1); *Persicaria thunbergii* (pol4) 28-ix-95 (1), 9-x-94 (1); *Eusteralis yatabeana* (lab1) 28-ix-95 (1); *Mosla dianthera* (lab3) 9-x-94 (1)

*Phaenicia sericata*
*Eupatorium lindleyanum* (ast5) 9-x-94 (1)

*Stomorhina obsoleta*
*Persicaria nipponensis* (pol2) 28-ix-95 (3); *Persicaria sieboldi* (pol3) 28-ix-95 (12); *Persicaria thunbergii* (pol4) 2-x-94 (1), 28-ix-95 (3), 9-x-94 (3); *Persicaria yokusaiana* (pol5) 9-x-94 (3); *Eusteralis yatabeana* (lab1) 17-ix-94 (3), 28-ix-95 (2); *Eupatorium lindleyanum* (ast5) 17-ix-94 (1), 28-ix-95 (33), 9-x-94 (1); *Kalimeris pinnatifida* (ast8) 28-ix-95 (16); *Prenanthes tanakae* (ast11) 9-x-94 (23)

sp. 1
*Eupatorium lindleyanum* (ast5) 28-ix-95 (1)

### Tachinidae

*Echinomyia mikado*
*Persicaria thunbergii* (pol4) 9-x-94 (1); *Senecio pierotii* (ast12) 14-v-94 (1)

*Eutachina* sp.
*Oenanthe javanica* (umb1) 16-viii-94 (1)

*Gymnosoma* sp.
*Galium trifidum* var. *brevipedunculatum* (rub1) 30-vi-95 (1)

*Masicera* sp.
*Eusteralis yatabeana* (lab1) 17-ix-94 (2); *Eupatorium lindleyanum* (ast5) 9-x-94 (1)

*Servillia jokovlewii*
*Lycopus ramosissimus* var. *japonicus* (lab2) 28-ix-95 (1)

*Thelaira nigripes*
*Persicaria thunbergii* (pol4) 2-x-94 (1); *Salvia japonica* (lab5) 9-x-94 (1)

*Thelaira* sp.
*Senecio pierotii* (ast12) 14-v-94 (1)

sp. 1
*Eupatorium lindleyanum* (ast5) 28-ix-95 (1)

## LEPIDOPTERA

### Pyralidae

*Hymerria recurvalis*
*Eusteralis yatabeana* (lab1) 17-ix-94 (4), 28-ix-95 (2); *Salvia japonica* (lab5) 9-x-94 (2)

*Diasemia litterata*
*Sagittaria trifolia* (ali2) 17-ix-94 (2)

### Hesperiidae

*Parnara guttata guttata*
*Persicaria thunbergii* (pol4) 2-x-94 (2), 28-ix-95 (1); *Lythrum anceps* (lyt1) 16-viii-94 (4), 17-ix-94 (5), 28-ix-95 (2); *Oenanthe javanica* (umb1) 16-viii-94 (1); *Eusteralis yatabeana* (lab1) 16-viii-94 (3), 17-ix-94 (1); *Prenanthes tanakae* (ast11) 9-x-94 (3)

*Pelopidas mathias oberthueri*
*Persicaria thunbergii* (pol4) 28-ix-95 (1); *Oenanthe javanica* (umb1) 28-vii-94 (1); *Prenanthes tanakae* (ast11) 9-x-94 (1)

*Polytremis pellucida pellucida*
*Lysimachia fortunei* (pri1) 16-viii-94 (1); *Cirsium japonicum* (ast2) 16-viii-94 (1)

*Thoressa varia*
*Senecio pierotii* (ast12) 14-v-94 (1)

### Papilionidae

*Papilio helenus nicconicolens*
*Clerodendrum trichotomum* (ver1) 16-viii-94 (1); *Weigela hortensis* (cap1) 14-v-94 (2)

### Pieridae

*Eurema hecabe*
*Adenophora triphylla* var. *japonica* (cam1) 16-viii-94 (1)

**Lycaenidae**

*Everes argiades hellotia*
*Alisma canaliculatum* (ali1) 28-vii-94 (1)

*Lycaena phlaeas daimio*
*Kalimeris pinnatifida* (ast8) 28-ix-95 (1)

**Nymphalidae**

*Argynnis paphia tsushimana*
*Prenanthes tanakae* (ast11) 9-x-94 (1); *Taraxacum japonicum* (ast13) 28-ix-95 (2)

**Satyridae**

*Ypthima argus*
*Eupatorium chinense* (ast4) 16-viii-94 (1)

**HYMENOPTERA**

**Tenthredidae**

*Lagidina platyeerus*
*Iris laevigata* (iri1) 1-vi-95 (2)

sp. 1
*Senecio pierotii* (ast12) 17-iv-94 (1)

sp. 2
*Mosla dianthera* (lab3) 28-ix-95 (1)

**Argidae**

*Arge nipponensis*
*Cardamine lyrata* (bra1) 1-vi-95 (1)

**Ichneumonidae**

sp. 1
*Persicaria thunbergii* (pol4) 9-x-94 (1)

sp. 2
*Persicaria thunbergii* (pol4) 9-x-94 (1)

sp. 3
*Monochoria korsakowii* (pon1) 28-ix-95 (1)

sp. 4
*Persicaria comspicua* (pol1) 9-x-94 (1)

sp. 5
*Iris laevigata* (iri1) 1-vi-95 (2)

sp. 6
*Taraxacum japonicum* (ast13) 28-ix-95 (1)

**Braconidae**

*Agathis* sp.
*Persicaria sieboldi* (pol3) 28-ix-95 (9); *Persicaria thunbergii* (pol4) 28-ix-95 (7); *Kalimeris pinnatifida* (ast8) 28-ix-95 (1); *Kalimeris yomena* (ast9) 2-x-94 (1)

*Chelonus* sp.
*Persicaria thunbergii* (pol4) 28-ix-95 (1)

*Odontobracon* sp.
*Persicaria thunbergii* (pol4) 9-x-94 (1)

sp. 1
*Kalimeris pinnatifida* (ast8) 28-ix-95 (3)

sp. 2
*Kalimeris pinnatifida* (ast8) 28-ix-95 (1)

sp. 3
*Eusteralis yatabeana* (lab1) 17-ix-94 (1)

sp. 4
*Sagittaria trifolia* (ali2) 17-ix-94 (1)

sp. 5
*Lythrum anceps* (lyt1) 17-ix-94 (1)

sp. 6
*Lythrum anceps* (lyt1) 17-ix-94 (1)

**Eulophidae**

sp. 1
*Persicaria thunbergii* (pol4) 28-ix-95 (1)

**Chalcididae**

sp. 1
*Persicaria thunbergii* (pol4) 28-ix-95 (1); *Eupatorium chinense* (ast4) 16-viii-94 (1)

**Encyrtidae**

sp. 1
*Lythrum anceps* (lyt1) 17-ix-94 (3)

**Scolitidae**

*Campsomeris grossa*
*Eusteralis yatabeana* (lab1) 28-ix-95 (1)

**Formicidae**

sp. 1
*Senecio pierotii* (ast12) 14-v-94 (6)

**Eumenidae**

*Stenodynerus* sp.
*Kalimeris yomena* (ast9) 5-viii-95 (1)

*Eumenes micado*
*Ampelopsis brevipedunculata* var. *heterophylla* (vit1) 16-viii-94 (1)

*Oreumenes decoratus*
*Eusteralis yatabeana* (lab1) 28-ix-95 (1)

*Eumenes samurai*
*Lespedeza bicolor* (leg2) 28-ix-95 (1); *Ampelopsis brevipedunculata* var. *heterophylla* (vit1) 16-viii-94 (3); *Kalimeris yomena* (ast9) 2-x-94 (1)

**Vespidae**

*Vespa simillima xanthoptera*
*Persicaria thunbergii* (pol4) 9-x-94 (1)

*Polistes chinensis antennalis*
*Persicaria thunbergii* (pol4) 2-x-94 (1); *Oenanthe javanica* (umb1) 16-viii-94 (1); *Lycopus ramosissimus* var. *japonicus* (lab2) 28-ix-95 (4)

*Vespula lewisii*
*Eupatorium lindleyanum* (ast5) 28-ix-95 (1)

*Vespula vulgaris*
*Prenanthes tanakae* (ast11) 9-x-94 (1)

**Pompilidae**

*Cyphononyx dorsalis*
*Lycopus ramosissimus* var. *japonicus* (lab2) 28-ix-95 (1)

*Anoplius eous*
*Oenanthe javanica* (umb1) 16-viii-94 (1)

**Sphecidae**

*Larra* sp.
*Mosla dianthera* (lab3) 28-ix-95 (1)

*Psen* sp.
*Oenanthe javanica* (umb1) 28-ix-95 (1)

**Colletidae**

*Hylaeus macilentus*
*Stellaria media* (car1) 22-vi-94 (1); *Cardamine lyrata* (bra1) 1-vi-95 (1); *Lythrum anceps* (lyt1) 17-ix-94 (1); *Oxalis corniculata* (oxa1) 30-vi-95 (2); *Eusteralis yatabeana* (lab1) 17-ix-94 (1); *Prunella vulgaris* ssp. *asiatica* (lab4) 30-vi-95 (9); *Ixeris debilis* (ast6) 30-vi-95 (2); *Sagittaria trifolia* (ali2) 5-viii-95 (1); *Monochoria korsakowii* (pon1) 2-x-94 (1); *Iris laevigata* (iri1) 1-vi-95 (8)

*Hylaeus floralis*
*Persicaria thunbergii* (pol4) 28-ix-95 (1); *Oxalis corniculata* (oxa1) 28-ix-95 (1); *Lycopus ramosissimus* var. *japonicus* (lab2) 28-ix-95 (2); *Mosla dianthera* (lab3) 28-ix-95 (1), 9-x-94 (1); *Prunella vulgaris* ssp. *asiatica* (lab4) 30-vi-95 (1); *Kalimeris yomena* (ast9) 2-x-94 (1); *Monochoria korsakowii* (pon1) 28-ix-95 (1); *Iris laevigata* (iri1) 1-vi-95 (1)

*Hylaeus noomen*
*Persicaria thunbergii* (pol4) 28-ix-95 (1); *Rosa multiflora* (ros2) 30-vi-95 (4); *Lythrum anceps* (lyt1) 17-ix-94 (1); *Oxalis corniculata* (oxa1) 28-ix-95 (3); *Mosla dianthera* (lab3) 28-ix-95 (1); *Eupatorium lindleyanum* (ast5) 28-ix-95 (1); *Monochoria korsakowii* (pon1) 2-x-94 (2), 28-ix-95 (8); *Monochoria vaginalis* (pon2) 28-ix-95 (8)

*Colletes palellatus*
*Persicaria sieboldi* (pol3) 28-ix-95 (1); *Kalimeris pinnatifida* (ast8) 28-ix-95 (2)

**Halictidae**

*Lasioglossum affine*
*Sagittaria trifolia* (ali2) 16-viii-94 (1); *Iris laevigata* (iri1) 1-vi-95 (1)

*Lasioglossum allodalum*
*Ranunculus japonicus* (ran1) 14-v-94 (1); *Monochoria korsakowii* (pon1) 28-ix-95 (1)

*Lasioglossum exiliceps*
*Mosla dianthera* (lab3) 9-x-94 (1); *Eupatorium lindleyanum* (ast5) 17-ix-94 (2)

*Lasioglossum gorkiense*
*Justicia procumbens* (aca1) 28-ix-95 (1)

*Lasioglossum japonicum*
*Ranunculus japonicus* (ran1) 14-v-94 (2); *Lycopus ramosissimus* var. *japonicus* (lab2) 28-ix-95 (1); *Mosla dianthera* (lab3) 28-ix-95 (1)

*Lasioglossum mutilum*
*Adenophora triphylla* var. *japonica* (cam1) 16-viii-94 (1); *Alium grayi* (lil1) 22-vi-94 (1)

*Lasioglossum percrassicepes*
*Nymphaea marliacea* (nym1) 30-vi-95 (1); *Sagittaria trifolia* (ali2) 16-viii-94 (1), 28-vii-94 (1); *Monochoria korsakowii* (pon1) 28-ix-95 (1), 28-vii-94 (3)

*Lasioglossum scitulum*
*Cirsium japonicum* (ast2) 22-vi-94 (1)

*Lasioglossum sibiriacum*
*Ranunculus japonicus* (ran1) 14-v-94 (2); *Cardamine lyrata* (bra1) 1-vi-95 (1); *Potentilla egedei* var. *grandis* (ros1) 1-vi-95 (1); *Oenanthe javanica* (umb1) 16-viii-94 (1); *Solanum melongena* (sol1) 5-viii-95 (1); *Mosla dianthera* (lab3) 9-x-94 (1); *Justicia procumbens* (aca1) 28-ix-95 (1); *Cirsium japonicum* (ast2) 22-vi-94 (1); *Taraxacum japonicum* (ast13) 17-iv-94 (1); *Sagittaria trifolia* (ali2) 16-viii-94 (1); *Monochoria korsakowii* (pon1) 16-viii-94 (1); *Iris laevigata* (iri1) 1-vi-95 (7)

**Andrenidae**

*Andrena knuthi*
*Ranunculus japonicus* (ran1) 14-v-94 (2); *Senecio pierotii* (ast12) 17-iv-94 (2); *Taraxacum japonicum* (ast13) 14-v-94 (2)

*Andrena kaguya*
*Taraxacum japonicum* (ast13) 17-iv-94 (1)

*Andrena minutula*
*Ranunculus japonicus* (ran1) 14-v-94 (1)

**Megachilidae**

*Megachile tsurugensis*
*Lespedeza bicolor* (leg2) 28-ix-95 (1); *Ampelopsis brevipedunculata* var. *heterophylla* (vit1) 16-viii-94 (1); *Kalimeris pinnatifida* (ast8) 28-ix-95 (1); *Prenanthes tanakae* (ast11) 9-x-94 (1); *Sagittaria trifolia* (ali2) 16-viii-94 (1)

*Megachile nipponica*
*Lysimachia fortunei* (pri1) 16-viii-94 (1); *Ampelopsis brevipedunculata* var. *heterophylla* (vit1) 16-viii-94 (1); *Prunella vulgaris* ssp. *asiatica* (lab4) 17-ix-94 (1), 30-vi-95 (1); *Eupatorium chinense* (ast4) 16-viii-94 (1)

*Osmia taurus*
*Senecio pierotii* (ast12) 17-iv-94 (1)

**Anthophoridae**

*Nomada fukuiana*
*Taraxacum japonicum* (ast13) 14-v-94 (1)

*Nomada nipponica*
*Ixeris dentata* (ast7) 1-vi-95 (1); *Taraxacum japonicum* (ast13) 1-vi-95 (1), 17-iv-94 (1)

*Ceratina esakii*
*Prunella vulgaris* ssp. *asiatica* (lab4) 30-vi-95 (1)

*Ceratina flavipes*
*Prunella vulgaris* ssp. *asiatica* (lab4) 30-vi-95 (1); *Ixeris dentata* (ast7) 14-v-94 (2)

*Ceratina japonica*
*Ranunculus japonicus* (ran1) 14-v-94 (3); *Aeschynomene indica* (leg1) 28-ix-95 (1); *Justicia procumbens* (aca1) 28-ix-95 (3); *Senecio pierotii* (ast12) 14-v-94 (4)

*Xylocopa appendiculata*
*Prunella vulgaris* ssp. *asiatica* (lab4) 22-vi-94 (1); *Weigela hortensis* (cap1) 14-v-94 (1); *Cirsium sieboldii* (ast3) 28-ix-95 (1)

**Apidae**

*Apis cerana*
*Persicaria nipponensis* (pol2) 28-ix-95 (1); *Persicaria sieboldi* (pol3) 28-ix-95 (4); *Persicaria thunbergii* (pol4) 2-x-94 (1), 28-ix-95 (4), 9-x-94 (2); *Mosla dianthera* (lab3) 2-x-94 (1); *Salvia japonica* (lab5) 9-x-94 (1); *Justicia procumbens* (aca1) 28-ix-95 (1); *Bidens frondosa* (ast1) 2-x-94 (1), 28-ix-95 (1); *Kalimeris yomena* (ast9) 9-x-94 (1); *Taraxacum japonicum* (ast13) 14-v-94 (2)

*Bombus diversus*
*Solanum melongena* (sol1) 5-viii-95 (1); *Prunella vulgaris* ssp. *asiatica* (lab4) 22-vi-94 (1); *Justicia procumbens* (aca1) 28-ix-95 (1); *Adenophora triphylla* var. *japonica* (cam1) 28-ix-95 (1); *Hosta albo-marginata* (lil2) 16-viii-94 (1), 28-vii-94 (1), 5-viii-95 (1)

*Bombus hypocrita*
*Justicia procumbens* (aca1) 28-ix-95 (1)

## EXPLANATION OF PLATE 1

Views of the study site at Nakaikemi marsh and some flowers studied for anthophilous communities. **A**, Typical view of a traditional rice field and a channel colonized by *Zizania latifolia* and *Hydrocharis dubia*. **B**, *Iris laevigata* flowering in a sedge swamp in mid May. **C**, a channel penetrating reed swamps and abandaned rice fields. **D**, *Senecio pierotii* flowering in a reed swamp in mid May. **E**, *Eusteralis yatabeana* flowering in a marsh in late September. **F**, *Eupatorium lindleyanum* flowers visited by a scarabaeid beetle, *Oxycetonia jucunda*. **G**, a *Monochoria korsakowii* flower visited by a syrphid fly, *Episyrphus balteatus*. **H**, *Monochoria korsakowii* flowering in a *Typha* marsh in late September. **I**, an *Iris laevigata* flower visited by a colletid bee, *Hylaeus macilentus*. **J**, a *Limnophila sessiliflora* flower visited by a syrphid fly, *Sphaerophoria macrogaster* in late September. **K**, a male flower of *Hydrocharis dubia* visited by a muscid fly, *Limnophora* sp., in late September. **L**, a syrphid fly, *Platycheirus pennipes*, visiting and feeding pollen of *Scirpus triqueter* in late June.


M. KATO and R. MIURA: *Flowering phenology and anthophilous insect community at a threatened natural lowland marsh at Nakaikemi in Tsuruga, Japan*